X PLANES

No: 13

Richard P. Hallion

THE WRIGHT FLYERS 1899–1916

THE KITES, GLIDERS, AND AIRCRAFT THAT LAUNCHED THE "AIR AGE"

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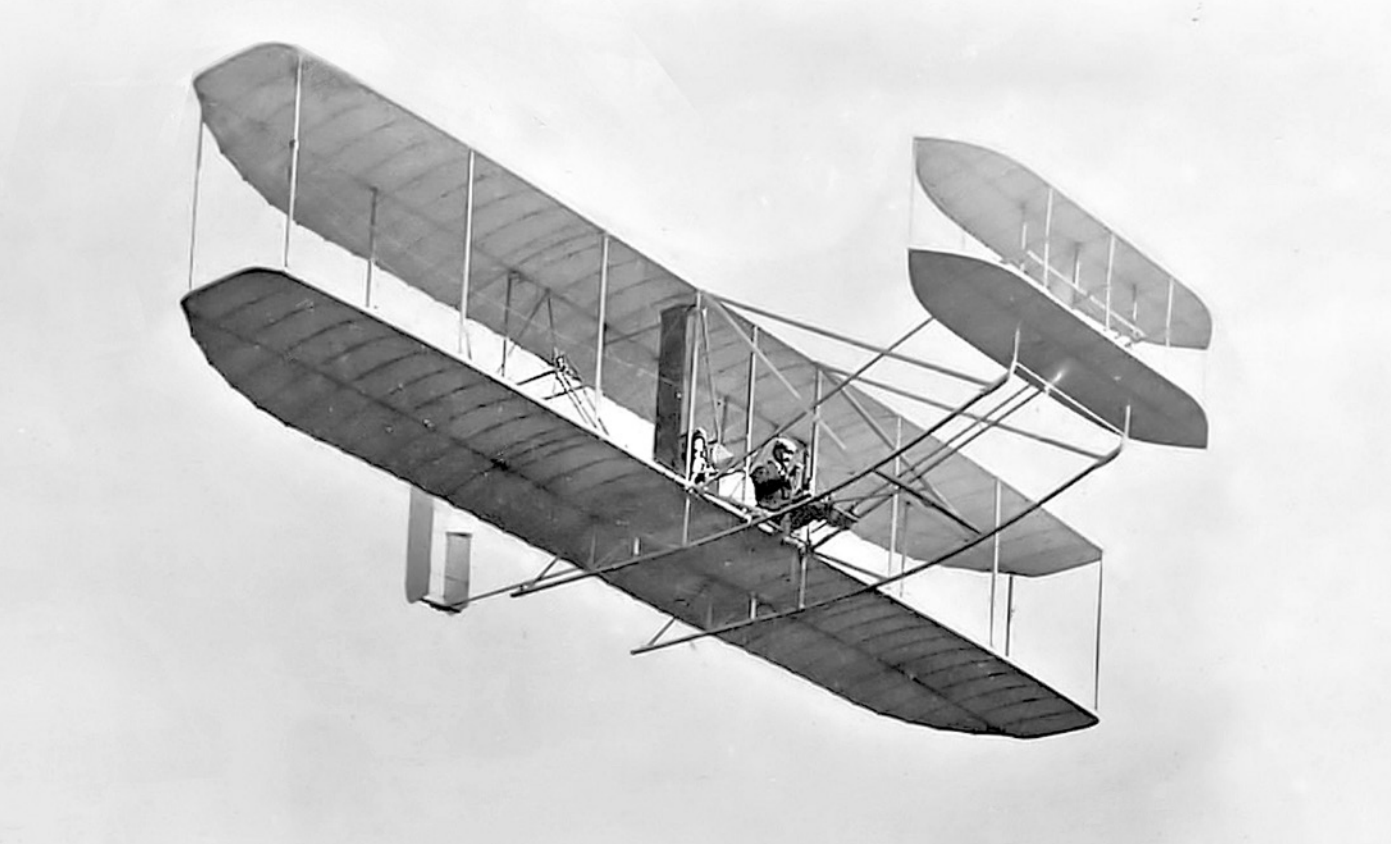
SERIES EDITOR TONY HOLMES



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CHAPTER ONE

INTRODUCTION

In the summer and fall of 1896, Augustus Herring and William Avery made dozens of flights in a glider designed by Octave Chanute on the Indiana dunes of Lake Michigan. Chanute's signature rectangular bridge-truss wing layout was adopted by the Wrights for their own subsequent kite, glider, and airplane designs. (US Library of Congress; hereafter LC)

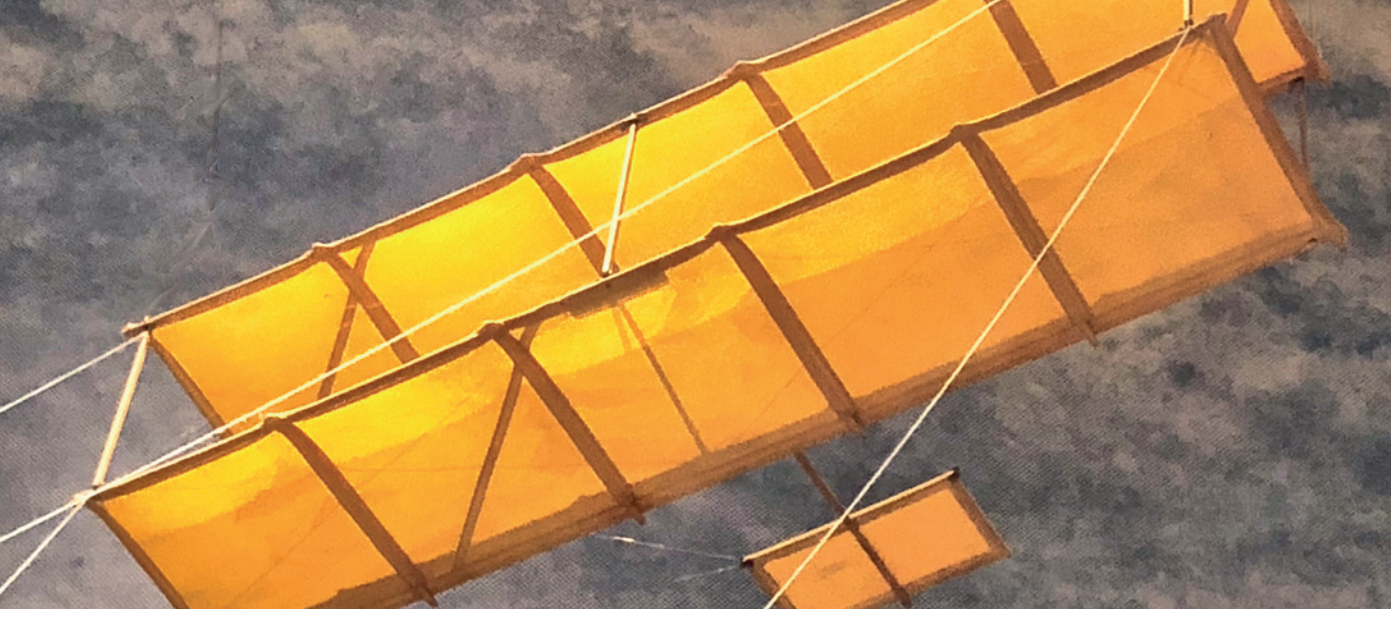
At the beginning of the 20th century, Orville and Wilbur Wright invented the airplane. By making the world's first powered, sustained, and controlled heavier-than-air flights – four in all – in the span of just 90 minutes on the cold and blustery morning of December 17, 1903, they launched the aerial age and secured their place in both global and aviation history. The image of their first flight constitutes one of the rare examples when a revolution in human history has been captured literally as it occurred (others are the first atomic explosion in 1945, the launch of *Sputnik* in 1957, and the first step by a human onto the moon in 1969).

Too-frequently portrayed as simply shrewd tinkerers and mechanics who, possessing a homespun "Yankee ingenuity," casually turned from making bicycles to inventing the airplane (thereby joining Benjamin Franklin, Ely Whitney, Robert Fulton, Cyrus McCormick, Samuel Morse, Thomas Edison, and Henry Ford in a pantheon of American inventors), the Wrights were actually practicing aeronautical engineers before the formal establishment of that field. They worked far in advance of any of their predecessors and virtually all of their contemporaries, and, in their progression onwards through curiosity, methodical study, and on to ground-and-flight experimentation, they both undertook the world's first successful "X-Plane" development program and established a template followed by subsequent developers. Their 1903 Kitty Hawk Flyer is the Ur-airplane from which all other post-1903 winged powered aircraft are derived.

Thus, as ancient Greeks credited Prometheus with bringing mortals fire, so the Wright brothers, heirs of Prometheus, gave mortals wings

to move at will through the skies. But every success story has within it the threat of reversal, and so it is with the Wrights. If, like that mythic Titan, the two brothers – veritable Titans of the modern world – earned imperishable fame and lasting gratitude, so, too, did they likewise suffer afterwards, for, having invented the airplane, by the end of 1909, they had reached their peak. The Flyer design – twin pusher propellers chain-driven from a single engine, an open framework, canard elevator, and a skid landing gear – was overturned by newer European designs that not only flew, but flew better: easier, faster, higher, safer. Adopting Wright control concepts but stressing inherent stability, European designers effectively rethought the airplane as a tractor monoplane or biplane less than a decade after the Wrights had first flown at Kitty Hawk. It was their kind of airplane that went to war in 1914, not Wilbur and Orville's.

But for a decade, from 1899 through to early 1909, the Wrights had been dominant in flight, making notable contributions both to the understanding and practice of flying, but also to the design and operation of aircraft, and the development of what would emerge as a global air-mindedness. Before reviewing their work, it is well to remember what Le Corbusier (Charles-Édouard Jeanneret), the great Swiss-French architect and polymath – an individual with a keen eye for form and for function – said of the invention of flight, and, by extension, the Wrights and their work: "We may then affirm that the aeroplane mobilized invention, intelligence, and daring: *imagination* and *cold reason*. It is the same spirit that built the Parthenon."



CHAPTER TWO

FLYING TOYS AND WARPING KITES

THE WRIGHTS AND FLIGHT, 1878–1900

In the late summer of 1878, Bishop Milton Wright of the Church of the United Brethren in Christ took a business trip. Though theologically rigid and doctrinally disputatious in church matters, he was a deeply loving and kind father. Thus, upon his return, he greeted his young sons with something hidden in his hands, suddenly opening them wide to reveal a helicopter toy invented by France's Alphonse Pénaud. It shot to the ceiling, bobbing and weaving for several seconds before falling gently back to the floor, introducing Orville and Wilbur Wright, then seven and 11 years old, respectively, to mechanical flight. Over the next few years, as Orville recalled, "We built a number of copies of this toy, which flew successfully." Nearly two decades later, now established as successful Dayton, Ohio, printers and bicycle builders, the brothers retained their interest in aviation, following the exploits of Germany's Otto Lilienthal.

Together with his brother Gustav, Lilienthal – a trained engineer – experimented with models, tested aerofoils with a whirling arm test rig, studied bird flight, and risked his own life in a series of gliders he designed and tested, running down a small artificial hill he had raised in Lichterfelde (a Berlin suburb) and launching himself into the air, and continuing his experiments on the Gollenberg, in the Stöllner Hills near Rathenow. Altogether, Lilienthal made approximately

The first Wright design was a 5ft-span kite, flown at Dayton in 1899 to validate wing-warping. No photographs of it exist, but surviving drawings have enabled reproduction artworks to be created, such as this one, by historian-craftsman Rick Young, on loan to the National Air and Space Museum of the Smithsonian Institution. (Richard P. Hallion; hereafter RPH)

Wilbur (left) and Orville Wright (right) were insightful researchers and skilled craftsmen who were fascinated by all forms of transportation technology. The sons of a minister, they blended scrupulous integrity, physical courage, and an all-consuming work ethic. (US Library of Congress; hereafter LC)

2,000 flights, controlling his gliders by shifting his body weight. He even built the world's first production glider, his *Typ 11 Normal-Segelapparat* ("Standard soarer"), selling eight of them to enthusiasts in Europe, Russia, and America. His work had inspired others, among whom were Britain's Percy Pilcher, Ireland's George Francis Fitzgerald, Russia's Nikolai Zhukovskii, and America's Octave Chanute. On August 9, 1896, however, Lilienthal's work came to a crashing end: a fickle gust led to a fatal stall and fall that mortally injured the "Winged Prussian," who died early the next morning, after muttering one of aviation's most hallowed utterances, "*Opfer müssen gemacht werden*" ("Sacrifices must be made").

Lilienthal's death shocked the aeronautical world, but stimulated the Wrights to actively study flight. "We soon passed from the reading to the thinking, and finally to the working stage," Wilbur Wright recalled in an address before the Western Society of Engineers in 1901, adding:

"It seemed to us that the main reason why the problem had remained so long unsolved was that no one had been able to obtain any adequate practice. We figured that Lilienthal in five years of time had spent only about five hours in actual gliding through the air. The wonder was not that he had done so little, but that he had accomplished so much."

Lilienthal's death coincided with the near-death of Orville Wright from typhoid fever. As the younger Wright slowly recuperated, he and Wilbur pondered why Lilienthal crashed, concluding that shifting body weight clearly was insufficient to keep a glider in trim. So, as Orville recalled, "We at once set to work to devise a more efficient means of maintaining the equilibrium." Over the next several years they pondered the problem of heavier-than-air flight – at the same time wondering if they should enter the emerging auto industry. Their self-study convinced them they needed access to a wider range of expert opinion. As the brothers recalled in a 1908 article in *Century Magazine,* "We had taken up aeronautics merely as a sport. We reluctantly entered upon the scientific side of it. But we soon found the work so fascinating that we were drawn into it deeper and deeper."

Thus, on May 30, 1899, Wilbur Wright wrote to Dr Samuel Pierpont Langley, Secretary of the Smithsonian Institution (then America's most prestigious scientific body), asking for any information the Smithsonian had, adding, "I wish to avail myself of all that is already known and then if possible add my mite to help on the future worker who will attain final success." Though a prominent and largely self-taught astronomer, Langley was himself an aeronautical enthusiast, having built a succession of small steam-powered flying models he called "Aerodromes," launched from a houseboat moored in the Potomac River, and he was even then deep in developing a much larger "Great Aerodrome" powered by a gasoline engine and intended as a military reconnaissance airplane.

As Langley was a very real rival in the quest to achieve powered winged flight, it was perhaps fortunate that Wilbur's letter was delivered instead to his conscientious deputy, the paleontologist and naturalist Richard Rathbun, on whose desk it arrived late one Friday morning. To his everlasting credit, Rathbun – who had no interest in aviation and

had a habit of taking his Friday lunches at Washington's fashionable Cosmos Club – did not presume Wright's letter merely the work of some delusional Midwestern crank and simply toss it into the waste-bin or dictate some brief and negative response. Instead, he directed his staff to assemble a package of material to send to the Ohioan, went off to his lunch, and disappeared from the pages of aviation history, having unknowingly made the most profound and lasting contribution to human progress and civilization ever accomplished by a Smithsonian – or any other – bureaucrat.

Rathbun, through his conscientious dedication to duty, unknowingly became himself a catalyzing and consequential agent of change, and he should be hailed in executive training programs as both an inspiration and exemplar for bureaucrats everywhere. There is no evidence that he ever remembered, let alone comprehended, the significance of what he had done. Yet, had he not responded as he did, the Wrights, bereft of relevant information and at a personal crossroads between the aeronautical and automotive worlds, might well have abandoned aviation and turned to building automobiles – where their influence upon global history could hardly have been so great – and the first successful powered airplane would have been invented in France.

The package, which included works by Langley, Lilienthal, Octave Chanute, James Means, E. C. Huffaker, and Louis-Pierre Mouillard, effectively introduced the Wrights to scientific aeronautics. The brothers credited these publications – particularly Lilienthal and Mouillard – with having "infected us with their own unquenchable enthusiasm and transformed [our] idle curiosity into the active zeal of workers."

Their literature review convinced the brothers that simply emphasizing lift and power – as had Britain's Hiram Maxim, France's Clément Ader, and even America's Langley – would not enable success. Instead, like Lilienthal, Mouillard, and Chanute, one had to learn through incremental flights repeated over and over, finding what worked and, more importantly, what did not. Lilienthal had stated presciently that, "One can get a proper insight into the practice of flying only by actual flying experiments," adding, "It is in the air itself that we have to develop our knowledge." Wilbur Wright, speaking for the brothers in 1901, endorsed Lilienthal's views, comparing flying to riding a fractious horse. "If you are looking for perfect safety," he said, "you will do well to sit on a fence and watch the birds, but if you really wish to learn, you must mount a machine and become acquainted with its tricks by actual trial."

In 1896, Chanute, inspired by Lilienthal, built and test-flew a *Typ 11* glider, discovering it frustratingly "difficult to handle" and warning, "we found it cranky and uncertain in its action and requiring great practice," abandoning it six weeks prior to Lilienthal's fatal flight. Chanute and his associates Augustus Herring and William Avery next embarked on their own glider designs, where Chanute employed his skill as a bridge designer, conceptualizing multiple wings joined by struts and cross-braced to produce a self-reinforcing truss. Chanute thus gave to aviation the simple and easily

Although interested in flight from childhood, the Wrights might never have researched it or invented the airplane had it not been for the inspiration afforded by German gliding pioneer Otto Lilienthal, who intensively studied bird flight, conducted important (though flawed) experiments, and perished in 1896 in a glider accident. (LC)

Octave Chanute, the greatest American engineer of his time and the first individual to methodically trace the history of flight and aircraft design, was a generous and stalwart supporter of the brothers, corresponding with them and sharing information, equipment, and instrumentation. (LC)

calculated layout employed by subsequent biplanes, triplanes, and multiplanes. That included the Wrights, who adopted his design concepts for their own kites and gliders as they moved from the theoretical consideration to actual flight.

The Wrights confronted challenges in the four fields of aircraft design: aerodynamics, structures, propulsion, and controls. In aerodynamics, they drew upon the work of Sir George Cayley (whom Wilbur rightly credited as having "carried the science of flying to the point which it had never reached before and which it scarcely reached again during the last [i.e. 19th] century") and Lilienthal, whose tables on lift and drag constituted their main technical reference. For structures, they adopted the truss-structures of Chanute, which were amenable to straightforward stress calculation as opposed to more complex concepts such as Lilienthal and Ader's bat-like wings with their radial spars and wire bracing. For propulsion, they fortunately lived at the onset of the petroleum-fueled internal combustion revolution, pioneered by engine-inventors Nicolaus Otto, Karl Benz, Wilhelm Maybach, and Rudolf Diesel, and near an unusually skilled engine mechanic and machinist, Charles "Charlie" Taylor, who became their engine designer.

For control, they had to rely upon themselves. They recognized that an airplane necessarily moves in three dimensions, thus having to be controlled in longitudinal pitch (nose up, nose down), directional yaw (nose left, nose right), and lateral bank (e.g. roll, that is, wing up, wing down). Pitch could be controlled by having a small wing (which they termed a "front rudder," but which would now be called a "canard elevator") located ahead of the main wing – the position chosen primarily to afford some protective "fail gracefully" structure in front of the pilot to avoid serious injury or death in the event of a crash (a lesson learned from Lilienthal's fatal accident). The brothers would not address directional control until 1902, when they installed a movable rudder on one of their gliders, as subsequently discussed.

Controlling banking posed a challenge. The brothers recognized that banking really involved differentially changing the lifting properties of the wings so that one lost lift while the other gained greater lift, the latter rolling upwards, pivoting about the longitudinal axis of the airplane, as the opposing lift-bereft wing rolled downwards. Orville envisioned a wing having pivoted outer portions rotated by a long shaft to change their lifting properties, but Wilbur conceptualized by fortuitous accident a simpler wing-warping concept. While talking to a customer in their bicycle shop and absent-mindedly toying with a pasteboard tire box, he suddenly realized that by holding it horizontally between the palms of his hands, and then twisting the box ends, he could flex the top and bottom surfaces of the box, which were analogous to the upper and lower wings of a biplane.

"From this," Orville recalled, "it was apparent that the wings of a machine of the Chanute double-deck [i.e. biplane] type, with the fore-and-aft trussing removed, could be warped in like manner so that in flying, the wings on the right and left sides could be warped so as to present their surface to the air at different angles of incidence, and thus secure unequal lifts on the two sides."

In theory, the Wrights had solved the banking problem: but would it work in practice? To find out, the brothers built a large biplane kite, having a light pine frame and simple rectangular planform wings spanning 5ft, with a wing chord (the distance from leading to trailing edge) of 13in. Interestingly, it utilized a small fixed horizontal stabilizer aft of the wing, in contrast to their subsequent canard configurations used for all other gliders and aircraft to 1910. Two sets of light cord lines ran to the wings, one set affixed to the top and bottom of the front support strut joining the upper and lower right wings at their wing tips, and the second set similarly attached to the front support strut joining the upper and lower left wing. The ends of each set of lines were attached to a short dowel, the top line to the top of the dowel, and the bottom line to the bottom of the dowel. The kite operator, facing the kite, thus held two dowels vertically, one in his left and one in his right hands, the left-hand dowel controlling the upper and lower lines running to the kite's right wing, and the right-hand dowel controlling the upper and lower lines running to the left wing. Differentially twisting the dowels in opposing directions (i.e. clockwise and counterclockwise) warped the wings.

The brothers flew the kite over the late summer of 1899, from a field on the outskirts of Dayton, in front of curious schoolboys likely wondering why grown men were playing with kites. The trials proved that wing-warping worked: the brothers had overcome their first great challenge, finding a means of laterally controlling an airplane. In retrospect, the 1899 kite was one of the most important flying experiments ever undertaken, occupying a position at least as significant as Alphonse Pénaud's rubber-band-powered *planophore* of 1871, the world's first powered inherently stable aircraft capable of sustained flight. Both today would be considered sub-scale technology demonstrators.

But sadly, like Pénaud's model, the brothers' 1899 kite did not survive. Over the course of their work, the Wrights showed surprising indifference towards the fate of their material artifacts: indeed, it was only by the greatest of good fortune that several key Wright airplanes – even the Wright 1903 Flyer, the most famous and significant airplane in aviation history – survived. None of their gliders or kites did; as for the 1899 kite, the brothers broke it up in about 1905, following experiments on developing an automatic stabilizer.

SPECIFICATIONS FOR THE WRIGHT 1899 WING-WARPING KITE			
Wingspan	5ft 0in.	**Length**	2ft 2.88in. (est.)
Wing chord	1ft 1in.	**Aerofoil camber**	1 in 23 (1/23) (est.)
Wing gap	1ft 0in. (est.)	**Structure:**	Pine, cotton cloth, cord
Wing area	10.83sq ft		
Note:	The Wrights admirably documented their work but did not preserve technical drawings and consistent dimensional data for their individual aircraft. Thus, sources present a mix of often conflicting or contradictory information. This table and those that follow present what the author believes is the most accurate data. Information that cannot be determined with exactitude is indicated by a qualifying "est." or "approx."		

CHAPTER THREE

ON TO KITTY HAWK

On the advice of the US Weather Bureau, the Wright brothers selected Kitty Hawk, on the Outer Banks of North Carolina, for their flight research activities, for its winds were stronger and more consistent than those on the shores of the Great Lakes. Here is their camp, seen from the north in 1900. (LC)

THE WRIGHT 1900 AND 1901 GLIDERS

As 1899 rolled into 1900 and a new century, the Wrights were ready to go beyond toys and kites to piloted gliders. The flatlands around Dayton did not experience the steady, strong winds the brothers sought, and they thought they might test their gliders on the windy shores of Lake Michigan, like Chanute, but Chanute suggested either the Pacific or Atlantic coasts. Thus, in November 1899, the brothers sought advice from the US Weather Bureau, learning the most suitable spot was Kitty Hawk, a small fishing village on the Outer Banks of North Carolina.

The Wrights next contacted Octave Chanute, Wilbur writing to him on May 13, 1900, and (somewhat tongue-in-cheek) introducing himself to the old pioneer by stating, "I have been afflicted with the belief that flight is possible to man." He outlined the brothers' proposed plans, including developing a training rig consisting of a counterbalanced rope and tower from which the brothers could practice tethered flying before proceeding to untethered flight trials, and asked for some information on British glider pilot Percy Pilcher's experiments. (Pilcher, alas, had perished the previous September when his Lilienthal-like glider had broken up in flight.) The letter marked the beginning of a correspondence that lasted until Chanute's death in 1910. The old pioneer, whose book *Progress in Flying Machines* was then both the definitive history of previous flight attempts and a seminal design reference, subsequently advised the brothers on numerous matters. When Wilbur informed him on August 10, 1900, that they were designing a glider, Chanute helpfully recommended

using "sapwood, clear, straight-grained, and thoroughly seasoned," and sent them his own recipe for varnish as well.

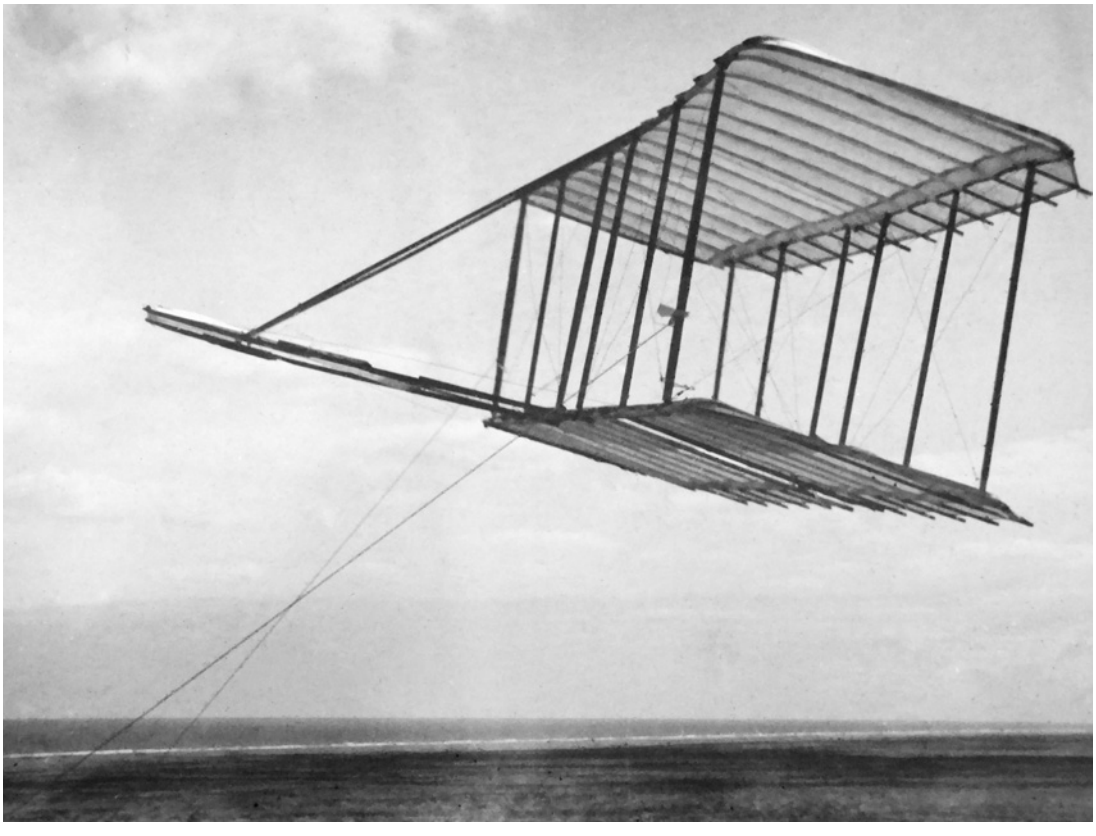
That same month, Wilbur wrote to Joseph Dosher, the chief of the Kitty Hawk weather station, requesting information on Kitty Hawk, receiving an immensely detailed response from W. J. "Capt Bill" Tate, the local postmaster. Greatly encouraged, Wilbur scouted Kitty Hawk the next month, taking parts of the new glider with him, and narrowly avoiding disaster on a stormy night passage across Albemarle Sound in a leaky, vermin-ridden, wind-battered, and wave-tossed schooner. Once safely ashore, he selected the dunes of Kitty Hawk for the brothers' research site, and subsequently arranged for them to take up temporary residence with Tate and his family, until they could set up their own tent camp for their final assembly and test site – which they did on October 4, on open dunes roughly a half-mile away from the Tate home.

Kitty Hawk's residents were tough fishing families that subsisted by braving the roiling waters off the Outer Banks and shipping, as Wilbur Wright noted, "tons and tons of fish" to Baltimore and other cities. Very quickly, the Wrights, the Tates, and many of the Outer Banks' locals developed strong (indeed, what would prove life-long) bonds of friendship, transcending any lingering bitterness from the American Civil War, which, just four decades earlier, had pitted North against South. Confederate North Carolina had suffered dreadful losses (as had Union Ohio), and it is remarkable how Kitty Hawk's residents, who (as Wilbur wrote) lived in a community "of little wealth and no luxurious living," set that aside, welcoming the "Yankee" brothers into their midst with a sincere and genuine warmth that the Wrights graciously returned. Indeed, the Tates and the local life-saving crew became vital partners as the Wrights flight-tested their gliders and the epochal 1903 powered Flyer. The Wrights' reputation soon also spread across the Sound to Elizabeth City, where the owner of the Kramer Brothers lumber company (which furnished wood to the brothers) pronounced them "right sensible-looking boys."

THE 1900 GLIDER

The brothers completed their first glider at the end of September 1900, Wilbur Wright writing to tell his father Milton on September 23, "It is not to have a motor and is not expected to fly in any true sense of the word. My idea is merely to experiment and practice with a view to solving the problem of equilibrium." He added reassuringly, "I am constructing my machine to sustain about five times my weight and am testing every piece. I think there is no possible chance of its breaking while in the air. If it is broken it will be by awkward landing. My machine will be trussed like a bridge and will be much stronger than that of Lilienthal."

The 1900 Glider had the same general configuration as the 1899 kite, lacking (as with the kite) any vertical surfaces, but having a controllable front canard; the pilot (whom the brothers called "the operator") lay on the lower wing facing forward, controlling the movable canard (which



In 1900, the Wrights made their first full-size man-carrying glider, with a wingspan of 17ft. They primarily flew it as a kite to assess its performance. (LC)

they called a "front rudder"). They chose the canard configuration for safety, since in the event of an accident the front structure and elevator would absorb impact loads, helping protect the pilot, as would his prone position, which had the added benefit of reducing the pilot's profile drag to about a fifth of a Lilienthal- or Chanute-like hang glider.

After completing the glider, the Wrights commenced flying on October 5 at Kill Devil Hill (which the brothers called "the Big Hill"), roughly 3 miles from their camp, making limited piloted trials totaling at most approximately 2 minutes. Thereafter, later on the 5th and sporadically through October 18, they flew it as a kite for two to four hours daily, to a maximum altitude of about 20ft. A wind-induced upset on October 10 forced three days of repairs before they resumed flying, otherwise they might have accomplished even more.

Despite the briefness of their flying experience, the brothers found the glider surprisingly easy to fly, Wilbur writing to Chanute after their return that, "The distance glided was between three and four hundred feet at an angle of one in six [i.e. 1ft of descent for every 6ft forward] and the speed at landing was more than double that of starting," and adding, "We found no difficulty in maintaining fore-and-aft balance. The ease with which it was accomplished was a matter of great astonishment to us." Overall it proved "a rather docile thing" – a wind of just 25mph sufficed to support the weight of a pilot.

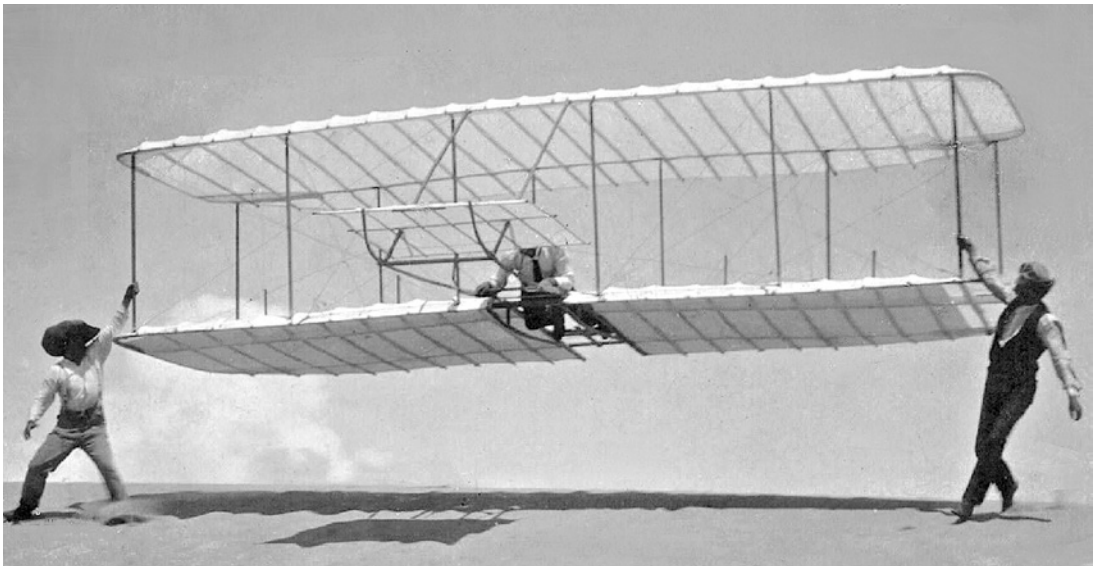
There were some surprises. The trials revealed the glider flew better backwards than forwards, an indication its canard configuration made it inherently longitudinally unstable. Despite this, the brothers persisted with the canard configuration for their subsequent designs, valuing safety over stability. They also discovered it produced insufficient lift, causing Wilbur to write in his notebook, "Either the curvature or the area should have been greater." It was an indication that the Lilienthal tables upon which they based their calculations of lift and drag were amiss. Characteristically, the brothers abandoned their 1900 Glider on the dunes when they returned to Dayton, Mrs Tate thriftily salvaging its pricy French sateen cotton to make dresses for her children. The remains disappeared for good in July 1901 when a 93mph gale – it may have been stronger still, as the weather station's anemometer blew away at that speed – swept it away.

SPECIFICATIONS FOR THE WRIGHT 1900 GLIDER			
Wingspan	17ft 0in.	**Aerofoil camber**	1 in 22 (1/22)
Wing chord	5ft 0in.	**Canard elevator area**	12sq ft (est.)
Wing gap	4ft 0in. (est.)	**Weight (empty)**	50lb (est.)
Length	10ft 0in.	**Weight (gross)**	190lb (est.)
Height	5ft 0in.	**Wing loading**	0.303lb/sq ft (as kite) 1.152lb/sq ft (gross)
Wing area	165sq ft		
Structure	Ash, pine, wire, French sateen fabric		
Flight record	Exact number of piloted flights unknown; total piloted flying time: 2 minutes (est.)		

THE 1901 GLIDER

Over the spring of 1901 the Wrights planned a return to Kitty Hawk the following September. They planned to make their camp more permanent too, by erecting a 16ft x 25ft frame building, 7ft in height, in which they would construct a new glider having larger wing and stabilizer areas. They also planned to carefully document their flight tests using precision instrumentation, seeking help from Chanute, who graciously loaned them a French-made Richard anemometer that was small enough to be installed on their glider, to measure air speed. Chanute delivered it in person on a trip he made to Dayton in late June, afterwards sending them a hand-held clinometer so that one brother could determine by direct observation and subsequent calculation the altitude achieved by the other in flight.

The pressure of other business – the brothers still ran their bicycle manufacturing, servicing, and sales operation – forced the Wrights to return to Kitty Hawk much earlier. They arrived in early July after the gale (accompanied by torrential rains) had swept across the Outer Banks, causing much damage, including destroying the remains of their 1900 Glider. They set to work building their large work shed (Orville subsequently called it "a grand institution") and digging a well. The arrival of Edward Huffaker, who came to test a glider he was making for Chanute, and George Spratt, a young friend of Chanute who had studied center of pressure travel on curved aerofoils and was eager to see gliders in



The Wrights returned to Kitty Hawk in 1901 with a new glider spanning 22ft with a 7ft wing chord, shown here being launched from a dune. It flew so badly that the brothers realized immediately that they needed to do further research on lifting properties, abruptly abandoning testing and returning to Ohio. (LC)

flight, interrupted their toil. Huffaker's machine was poorly designed – Chanute had already confided to the brothers in late June that it was "so weak" he feared it would not last long enough "to test the efficiency of the ideas in its design" – and it stood in marked contrast to the Wrights' own designs. Huffaker arrived coincident with (as Orville reported to his sister Katharine) "a swarm of mosquitoes which came in a mighty cloud, almost darkening the sun … the beginning of the most miserable existence I had ever passed through." The mosquitoes and their unwelcome guests (whom the Wrights hosted as a favor to Chanute) delayed construction of their new glider, which they did not finish until July 27.

As soon as they completed it on the 27th, the brothers took it to "the Big Hill." But to their shock, they found that the 1901 Glider flew worse, not better, than the 1900 design. Orville reported afterwards, "Our first experiments were rather disappointing. The machine refused to act like our machine last year and at times seemed to be entirely beyond control." Wilbur confided to his notebook on July 30:

"The most discouraging features of our experiments so far are these:

"1. The lift is not much over ⅓ that indicated by the Lilienthal tables.

"2. The control of our machine is not so good as last year.

"3. The resistance [i.e. drag] of the framing seems to be larger than we expected, being in fact nearly double.

"4. We have found that the machine, when once in free flight, does not tend to increase in speed as our last year's machine did.

"The good points as indicated by the experiments already made are these:

"1. The machine is strong. It has suffered no injury although very severely used in some forty landings.

"2. With less than an hour's practice we succeeded in getting a free flight of over 300ft at an angle [of descent] of 1 in 6.

"3. We have experimented safely with a machine of over 300sq ft surface in winds as high as 18mph.

"4. The lateral balance of the machine seems all that could be desired."

On August 5, Chanute arrived, remaining for nearly a week before departing for Chicago on August 11. Over that time he had the opportunity (as did Huffaker and Spratt) of witnessing the Wrights' endeavors, the Wrights disappointed that the poor performance of the glider meant they could only fly in substantial winds, frustrating their hopes of "experimenting in an 18-mile wind without much motion of the machine." Consequently, Wilbur noted, "It is necessary to glide in order to get a sustaining speed. Five minutes' practice in free flight is a good day's record. We have not yet reached so good an average as this even [sic]."

The glider did prove that the decision to employ a canard planform for crashworthiness was a correct one. During one glide where the left wing dropped, Wilbur tried to correct with wing warping but neglected to maintain elevator control, and the glider stalled and plunged into the ground, effectively emulating the Lilienthal crash exactly five years previously. This time the front structure and elevator absorbed the impact loads, so that even though Wilbur Wright was battered – he suffered a bruised nose and eye – he otherwise was unharmed.

But this was of little solace given its other problems, particularly its low lift, poor lateral control, and twitchy longitudinal control (the canard elevator required extreme inputs to affect even slight changes in pitch). If to Chanute, Huffaker, and Spratt the Wrights had achieved wonders with glides of over 300ft, the brothers had a very different reaction, recalling that, "Truth and error were everywhere so intimately mixed as to be undistinguishable." Discouraged, they left Kitty Hawk at daybreak on August 20, 1901. On the train back home, Wilbur confided to Orville that humans would not fly "for fifty years."

SPECIFICATIONS FOR THE WRIGHT 1901 GLIDER			
Wingspan	22ft 0in.	**Aerofoil camber**	Various between 1/12 and 1/19
Wing chord	7ft 0in.	**Canard elevator area**	18sq ft (est.)
Wing gap	4ft 8in.	**Weight (empty)**	108lb (est.)
Length	14ft 0in.	**Weight (gross)**	248lb (est.)
Height	6ft 0in. (est.)	**Wing loading**	0.351lb/sq ft (as kite)
Wing area	308sq ft		0.805lb/sq ft (gross)
Structure:	Ash, pine, wire, French sateen fabric		
Flight record:	At least 31 known piloted glides, possibly a dozen more. Total known piloted flying time 4 min 10 sec		

RECOVERY

Four erroneous assumptions plagued early aeronautics: Newton's "sine squared law," implying enormous drag rise accompanying even modest increases in a wing's angle of incidence (disproved by Britain's Francis Wenham); Samuel Langley's "Langley law," which held that the faster an airplane flew, the less its power requirements, stemming from limited low-speed tests he made that missed the rapid rise of parasitic drag at higher speeds; John Smeaton's calculation that the drag of a 1sq ft flat plate perpendicular to a 1mph airstream was 0.005lb (it was actually 0.0033lb), which others – though not he – termed

"Smeaton's Constant"; and Lilienthal's tables of lift and drag values. Back in Dayton, evaluating their experiences with the 1901 Glider, the brothers concluded its deficiencies stemmed from erroneous data – Smeaton's constant must be wrong and so too must Lilienthal's tables.

Rather than attempt rationalizing all the conflicting data from Lilienthal, Mouillard, Chanute, *et al.*, the brothers decided to develop their own, Wilbur recalling, "we cast it all aside and decided to rely entirely upon our own investigations." Smeaton, Lilienthal, and others had used whirling arm test rigs to develop their data, but the whirling arm had a built-in deficiency – after just a few revolutions, the air would start to circulate with the model, corrupting the fidelity of the test and leading to the generation of suspect data.

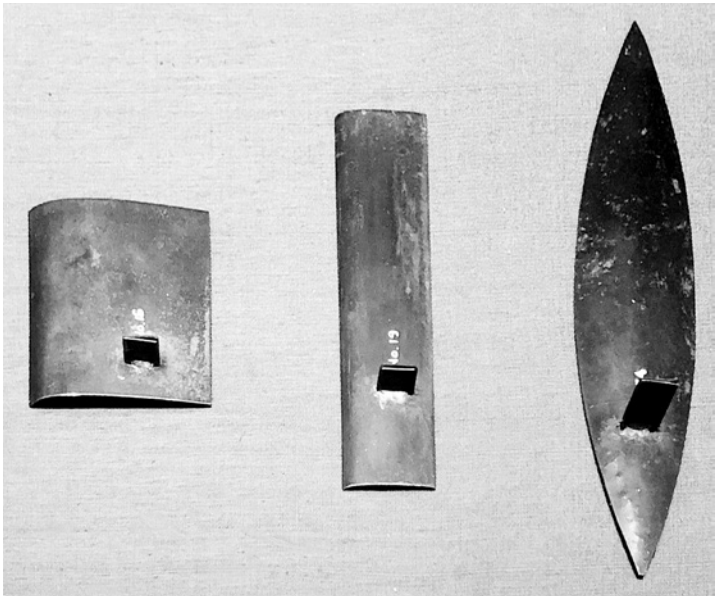
Rather than a whirling arm, the Wrights turned to their background as bicycle designers and manufacturers. Wilbur informed Chanute on September 26 that the brothers were about to undertake a simple test: they would place a 1sq ft Lilienthal aerofoil (which they called a "curve") and a 0.66sq ft flat plate (which they termed a "plane") at 90 degrees to each other on a horizontal (i.e. center axis vertical) bicycle wheel, the aerofoil being at a 5-degree angle-of-attack and the flat plate being perpendicular to the oncoming flow. If Lilienthal's data was correct, in this position the flow about the aerofoil would balance the flat plate. "If I find that it really does so," he said, "no question will remain in my mind that these tables are correct."

A little over a week later he wrote to Chanute again, informing him that the brothers had made the test, finding that instead of a 5-degree angle-of-attack, the aerofoil had to be at an 18-degree angle-of-attack to balance the plate. The "advantage of the curve over the plane was so much greater than we had expected" that the brothers immediately suspected the long-accepted – for fully 142 years – value of 0.005 for "Smeaton's Constant" was in error. Already the British meteorologist William Dines and America's Samuel Langley had concluded so, suggesting its true value was about 0.0032; now the Wrights found likewise, Wilbur stating, "I see no good reason for using a greater coefficient than 0.0033," and so it has remained, to this day.

For their investigation of Lilienthal's tables, they needed a more precise

Back in Dayton, the Wrights installed a lift-and-drag balance on a bicycle test rig, giving them the first measurable proof Lilienthal's data was faulty. Afterwards, they built a small wind tunnel and tested dozens of aerofoils and wing shapes, assembling their own data. (National Museum of the US Air Force; hereafter NMUSAF)

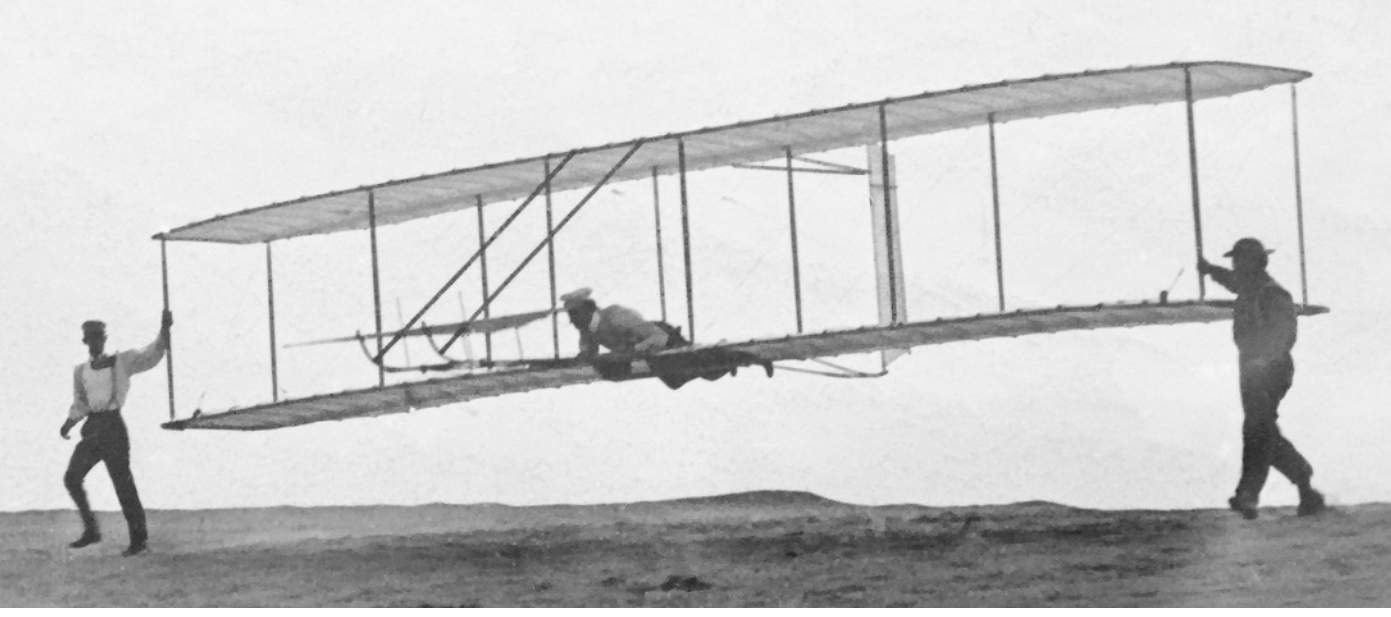
instrument, and for this they built a small wind tunnel with, for its time, a sophisticated balance for measuring the lift and drag of various aerofoils and wing configurations. They were not the first to invent or use a wind tunnel, however: both distinctions went to Britain's Francis Wenham and John Browning, who had invented the first tunnel in 1871, subsequently using it to disprove the fallacious "sine-squared law," and later Horatio Phillips had developed an even more sophisticated tunnel in which he accumulated detailed data on how varying cambers influenced lift generation.



Here are some of the shapes tested by the Wrights, and now on loan to the National Air and Space Museum of the Smithsonian Institution from the Franklin Institute. Note the variations in camber, aspect ratio, and planform. The brothers were the first airplane designers to use wind tunnel research to shape their craft. (RPH)

But the Wrights were the first to apply wind tunnel research to the design of actual aircraft. Over three weeks the Wrights evaluated 200 different wing shapes, settling on 38 for detailed testing, these reflecting various cambers and aspect ratios and planforms ranging from squares to long rectangles. They found their data differed so greatly from Lilienthal's that Wilbur informed Chanute on October 6, "I am now absolutely certain that Lilienthal's table is very seriously in error," though this did not diminish his great respect for the tragic German pioneer. "No one ought to spend time on flying problems without first acquainting himself with [Lilienthal's] book," Wilbur wrote to Chanute late that November, adding, "It is marvellous to me that Lilienthal should have found time for all the experimenting which the book indicates."

By early December 1901, the brothers had completed their tunnel experiments, and next turned to assembling a database they could rely upon for their new glider design, then took a pause – to Chanute's consternation – while Orville oversaw designing and building the next season's bicycles and Wilbur unsuccessfully defended his father in a contrived Church dispute that resulted, most unfairly, in Bishop Wright being expelled from his own Church conference. While 1901 had been a troubled year for the Wright family, the family's great strength was its internal unity, resilience, and unshakable sense of self-worth and purpose. All who knew Bishop Wright knew him to be a thoroughly decent and honorable man. And all who knew Orville and Wilbur Wright would never have doubted that their disappointments at Kitty Hawk were but a prelude to future success.



CHAPTER FOUR

"DAMNED IF THEY AIN'T FLEW!"

Wilbur Wright (left) and Dan Tate (right) launching Orville on October 10, 1902. Reflecting their tunnel research, the 1902 glider had much improved flying qualities. During testing, the brothers replaced its original fixed vertical double-surface fins with a moveable pivoted single-surface rudder, interconnected to the wing-warping. (LC)

THE 1902 GLIDER AND THE 1903 KITTY HAWK FLYER

The Wrights' bicycle business and their father's Church trial consumed the better part of the spring of 1902, but by summer the brothers focused once again on flight. Based on the data they had assembled from their tunnel trials, they designed a new glider of broader 32ft span, having a much greater aspect ratio – the ratio of wing span to wing chord – even though its wing area, at 305sq ft, actually was slightly less than the 1901 Glider's 308sq ft. Most distinctively, it was the first Wright machine with directionally stabilizing vertical fins, in the form of a twin-surface fixed (i.e. immoveable) vertical tail to prevent turn instability encountered with the earlier 1901 machine.

The Wrights left Dayton for Kitty Hawk on August 25, arriving on the 29th and discovering their shed damaged by winds. They immediately set to repairing it, and then quickly built an addition. With construction out of the way, on September 8 they started their new machine, incorporating some of the 1901 Glider's wing struts in its structure. They completed it on September 19, flying it later that day as a kite, assisted by Daniel Tate.

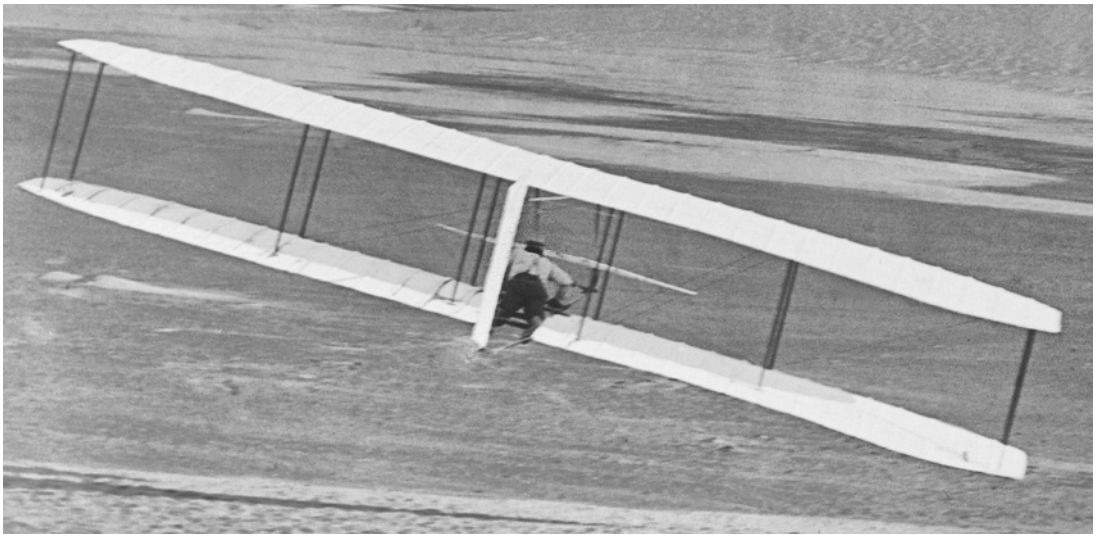
The first flights revealed a problem: while its lifting and longitudinal control properties were much superior to its predecessor, the Glider had insufficient inherent stability to avoid being upset by gusts. Having

spent much of their time at Kitty Hawk watching the flight of sea birds and buzzards, and noting that when confronting gusts birds actually adopted an anhedral – i.e. negative dihedral – wing configuration, they decided to immediately re-rig the glider with -4in. of anhedral at the wingtip, giving it a slightly drooped appearance when seen from the front. The brothers flew it as a kite, and finding it flew "beautifully," embarked on another round of free-flight glides, during which they routinely exceeded 500ft (though incorporating anhedral caused them serious lateral-directional stability problems on their later designs). By early October, Wilbur was writing to his father, "We now believe the flying problem is really nearing its solution," – far different than the pessimism he expressed to Orville on the train back to Dayton after the dismal 1901 trials.

SPECIFICATIONS FOR THE WRIGHT 1902 GLIDER			
Wingspan	32ft 1in.	**Aerofoil camber**	Various evaluated, 1/24 to 1/30
Wing chord	5ft (upper wing), 4ft 11.75in. (lower wing)	**Canard elevator area**	15sq ft
Wing gap	4ft 7in.	**Weight (empty)**	Approx 112lb
Length	16ft 1in.	**Weight (gross)**	Approx 252lb
Height	Approx 6ft 0in.	**Wing loading**	Approx 0.367lb/sq ft as kite, 0.826lb/sq ft with pilot
Wing area	305sq ft		
Structure:	Ash, pine, wire, tire cord (for bindings), French sateen fabric		
Flight record for 1902:	At least 700 known piloted glides (and possibly even 1,000) made during 1902, with total known 1902 piloted flying time of 17 min 25 sec in 86 known timed flights. Average known 1902 flight duration 12⅕ seconds		
Flight record for 1903:	At least 160 known piloted glides (and possibly more than 200) made during 1903, with total known 1903 piloted flying time of 18 min 17¾ sec in 24 known timed flights. Average known 1903 flight duration 45¾ seconds		
Note:	The brothers kept only sporadic records, and many flights were untimed, or at least not recorded. Thus, actual accumulated 1902 flying time could easily be significantly higher, totaling possibly 2⅓ hrs (based on 700 flights) up to to 3⅖ hrs (1,000 flights). 1903 records are more complete, with possible flying time for that year ranging from 2 hrs (based on 160 flights) to 2 hrs 30 min (200 flights). The difference in recorded timed flights reflects the brothers' growing skill as well as some of the changes they made to the 1902 Glider.		

But another problem had arisen, caused, ironically, by the anhedral modification. The anhedral exacerbated the glider's already marginal lateral (roll) stability, making it prone to ever-tightening turns that swiftly became unrecoverable spiraling descents into the dunes. The Wrights called this "well-digging" (flight researchers now term it spiral mode instability), and considered the glider "absolutely dangerous." Again, the decision to employ a front canard that doubled as a shock absorber proved successful, Wilbur recalling that one such crash left him sitting amidst "cloth and sticks in a heap, with me in the center without a bruise or a scratch."

To correct this problem, the Wrights made a momentous decision: changing the fixed twin-vertical-fin tail into a single-surface movable rudder, connecting the rudder cables to the wing warping so that, when the pilot warped the wings, the rudder would deflect, essentially making every bank a gentle turn. So modified, the 1902 Glider flew very well, the interlinked rudder and wing warping enabling the



Here, in a flight on October 24, 1902, Wilbur is using wing-warping and rudder deflection to correct for a gust-induced right bank, also deflecting the canard elevator to lower the nose. The 1902 Glider was the world's first controllable aircraft and the brothers flew it extensively, once making 250 flights in just two days. (LC)

operator (mostly Wilbur, but sometimes Orville) to cope with the destabilizing anhedral and the tendency to diverge into an ever-tightening spiral descent.

The Wrights now markedly extended their flying times and distances flown, attaining glides of over 600ft and nearly a half-minute in duration in flights witnessed by Chanute, Augustus Herring (another Chanute associate), Spratt (who had returned briefly to the Wright encampment), and also Lorin Wright, another brother. Jubilantly, they left Kitty Hawk on October 28, arriving in Dayton in the mid-afternoon of October 31. They had successfully developed and proven the world's first controllable aircraft. The next step was building a powered machine.

THE "WHOPPER FLYING MACHINE"

Up to the point where they began building their first powered airplane, the Wrights had been, effectively, masters of their own craft and fate. The problems they dealt with involved aerodynamics, structures, and controls, all subjects they had mastered. But the powered machine required mastery of flight propulsion, and that meant knowledge and ability to build a reliable, lightweight, and powerful engine.

Many pre-Wright aeronautical enthusiasts – most influentially Britain's John Stringfellow and William Henson and their "Aerial Steam Carriage" of 1843 – had proposed steam-powered aircraft, and some – France's Félix du Temple and Clément Ader, Britain's Hiram Maxim, Russia's Alexander Mozhaisky, and America's Samuel Langley – built a string of interesting models and mostly unsuccessful test rigs and full-size aircraft having steam propulsion, some of their engines being quite ingenious even if the aircraft they powered, alas, were not. But the steam engine – though later successfully applied to a few aircraft – was rapidly eclipsed by the spectacular development of the petroleum-fueled internal combustion engine. Langley switched from steam to

petroleum for his Great Aerodrome – and this was a technology that the Wrights personally had not mastered.

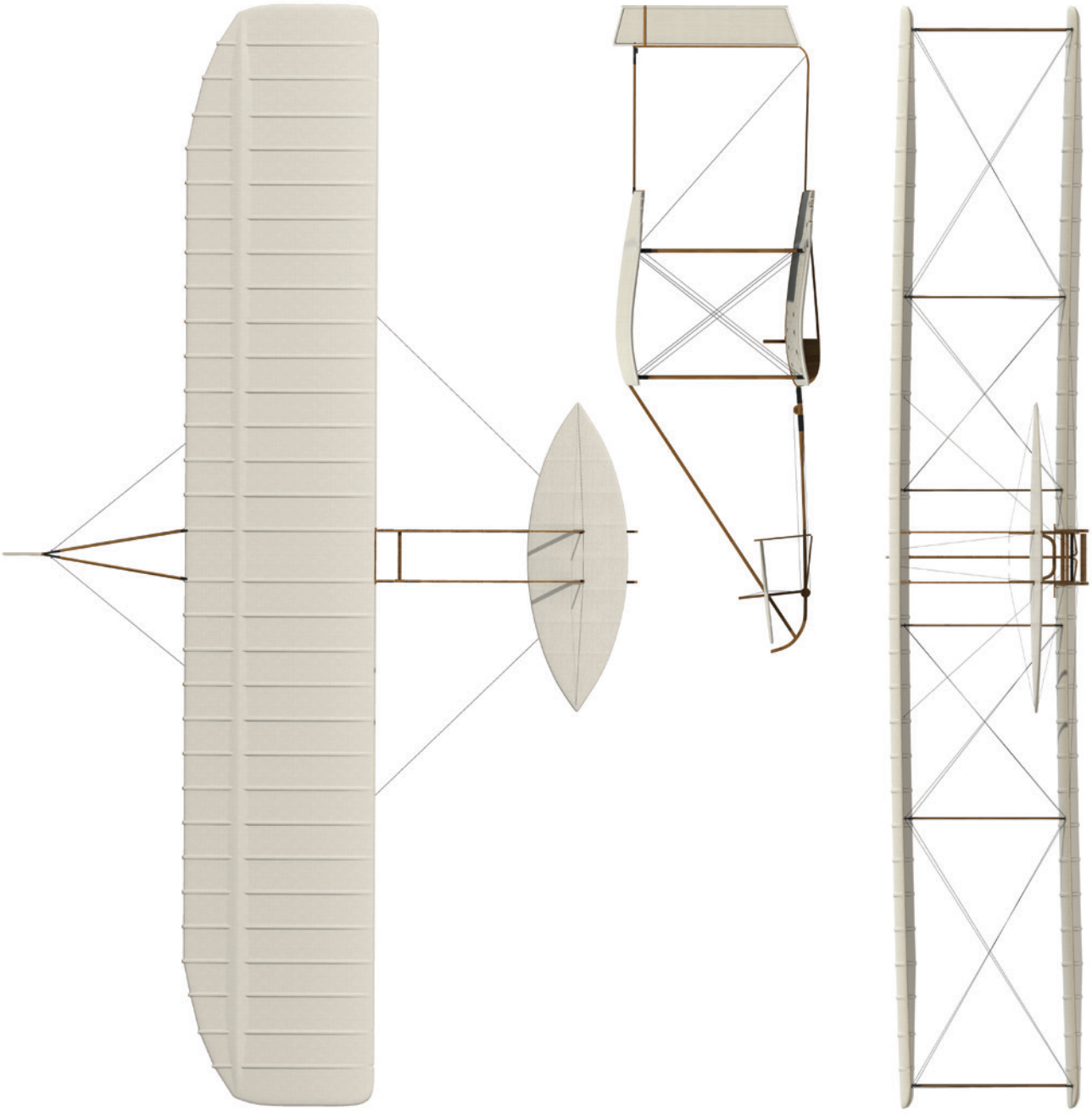
Fortunately, they employed a highly skilled machinist and mechanic who had done so: Charles "Charlie" Taylor. Taylor ran a local machine shop and had joined the Wrights as a full-time worker in 1901, so that the brothers could continue their bicycle enterprise while also pursuing flight. Working together, the Wrights and Taylor quickly designed and built an engine with four cylinders for smoothness and power, a one-piece lightweight aluminum crankcase and water jacket, a steel crankshaft (which Taylor cut from a 100lb steel block) and flywheel (which also ran an ignition-sustaining magneto), steel tube and brass end connecting rods, iron valve-heads with steel stems, and cast-iron cylinder barrels and pistons.

SPECIFICATIONS OF THE 1903 TAYLOR-WRIGHT ENGINE			
Design configuration	Four-cylinder horizontal inline with gravity fuel feed	**Bore and stroke**	4in. by 4in.
Cooling	Water	**Displacement**	201.1cu in.
Carburation	Surface type with no float	**Dimensions**	13⅝in. high, 23$\frac{1}{32}$in. wide, and 30$\frac{11}{16}$in. long
Ignition	Low-tension magneto (horseshoe magnets with exciting coils)	**Weight**	179lb without accessories, slightly more than 200lb with them
Power output	12.05hp at 1,090rpm	**Weight to power ratio**	16.6lb per hp

In the late fall of 1902, the Wrights and Taylor built a working model of the engine to ensure its basic functioning before proceeding with the actual engine. This demonstrator validated the design, and over the Christmas season they embarked on the actual engine, completing it and undertaking the first engine run on February 12. "Our motor on completion turned out to be a very pleasant surprise," Orville wrote years later; "instead of 8hp, for which we hoped but hardly expected, it [gave] us 13." "I must admit there wasn't much to that first motor," Taylor recalled a quarter-century after the first flight at Kitty Hawk, "but it worked."

Designing and building an engine was, of course, crucially important, but even more so was designing high-efficiency propellers. Surprisingly, though many pioneers worked with propellers, none but the Wrights had recognized their key attribute: they were neither paddles pushing the air around, nor screws that bored through the air (the expression "airscrew" a legacy of such thinking, notwithstanding). Rather, they were rotating wings following a helical path through the air and thereby translating the power of the engine into a forward lift vector pulling the aircraft into the air and sustaining its flight.

Coincident with designing their engine, the Wrights embarked on a short but aggressive research program to determine the best shape – i.e., the most lift-producing, hence efficient, while being sufficiently strong – for a propeller. The final design they chose was a long, elegant shape far removed from the fan-like or paddle-like designs of other inventors. Hewed from laminated spruce and symmetrically tapered on its leading and trailing edges, it had a diameter of 8½ft, a blade chord of 8in., and its twisting angle-of-attack varied from 8½ degrees at the tip to



"Orville Wright" in position in the 1903 Wright Flyer on exhibit at the National Air and Space Museum. Note his left hand controls pitch via the canard elevator (out of view), while he controls wing-warping via a hip cradle. Note also the Chanute-furnished anemometer to measure flight speed affixed to the wing strut to the pilot's right. (RPH)

4 degrees at the hub, and it usefully employed 66 percent of the power expended, roughly a third better than Langley had obtained with his Great Aerodrome. The Wrights used two pusher propellers, chain-driven off the Taylor-Wright engine (reflecting their experience with bicycle chains and sprockets), both to avoid adding torque problems on top of all the other challenges they faced, and to draw a larger mass air flow.

Their first powered airplane was essentially an enlarged 1902 Glider, with a 40ft 4in. wing assembled in three sections giving a total wing area of 510sq ft, a stronger reinforced structure, fabric covering both above and below the ribs, greater wing anhedral (-10in. at the tip), and with the glider's single-surface monoplane canard replaced by a biplane canard. Likewise, a pivoted movable double surface rudder, like a small biplane wing placed vertically, replaced the glider's single rudder.

Unlike the earlier 1900, 1901, and 1902 gliders, the 1903 Flyer had a rigidly braced wing center section carrying the engine, chain-drive and propeller mounts, and the pilot. Affixed to it was the skid landing gear, and the support structure for the canard elevator and biplane rudder. The outer portions of the wings were designed to be flexible so that the pilot could warp them. The Wrights covered the airplane with so-called "Pride of the West" muslin cotton fabric, showing here the same careful attention to detail that they gave the rest of the design. They sewed chord-wise pockets into the muslin (whose weave was set at a 45-degree angle relative to the wing chord, reversing as it was folded over the wing). They slipped the wing ribs into these pockets, which had a small cut-out at their bottom so that the end of the rib protruded, then slid the spanwise wing spar through the ribs, carrying the muslin fabric over the spar and around the leading edge of the wing, stretching it taut and tacking it in place. (Altogether, the Kitty Hawk Flyer used almost 10,000 tacks.)

Like the canard elevator, the Wrights had wisely chosen to place the engine and pilot side-by-side, fearing that if the engine was behind

the pilot, and became detached from its mounts in a crash, it could seriously injure or even kill him. Since the engine was significantly heavier than either brother, the upper and lower right wings had an additional 4in. of wingspan, giving the right wings a further 4.33sq ft of area over the left. The plane had a small quarter-gallon gasoline tank mounted at the top of the left inboard wing strut. The pilot lay prone in the warp-controlling hip cradle just to the left of the lower wing's centerline, with the heavy engine just to the right.

Unlike the Wrights' gliders, which could launch off dunes with one or two helpers, the powered machine – which the brothers called a Flyer, but referred to more informally as "the Whopper Flying Machine" – was, at nearly 750lb fully loaded, too heavy for such a launch method, and so the brothers designed a 60ft monorail take-off track that, assembled in sections, could be pointed into the wind, the Flyer perched on a small dolly with wheels that ran down the rail, dropping into the sand as the Flyer hopefully soared aloft. It was not, unlike later Wright monorails, a catapult – the plane would take off under its own power.

SPECIFICATIONS FOR THE WRIGHT 1903 FLYER			
Wingspan	40ft 4in.	**Aerofoil camber**	1/20
Wing chord	6ft 6in.	**Canard biplane elevator area**	48sq ft
Wing gap	Approx 6ft 2in.	**Vertical rudder area**	21sq ft
Length	21ft 1in.	**Weight (empty)**	Approx. 605lb
Height	Approx. 9ft 0in.	**Weight (gross)**	Approx. 745lb
Wing area	510sq ft	**Wing loading**	Approx. 1.46lb/sq ft
Structure:	Ash, spruce, wire, and "Pride of the West" muslin		
Engine:	One water-cooled four-cylinder 8¼hp to 16hp (12hp on first flight) horizontal inline of 201 cubic inch displacement running from 670rpm to 1,200rpm, chain-driving two contra-rotating ("handed") 8ft 6in. two-bladed propellers		
Maximum speed:	Approximately 30mph		
Flight record:	Four flights on December 17, 1903, approx 1 min 40 sec		

The Wrights left Dayton for Kitty Hawk on the morning of September 23, arriving at their camp just two days later, where they began another building, though they could not resist taking out the 1902 Glider, which had been left in storage at their camp, as the weather was so favorable for gliding. Over the next several days they completed upwards of 75 gliding flights in the 1902 Glider, the longest of which was just over a half-minute in duration. Pleased, Orville recorded in his diary that "our glides were higher and more spectacular than any heretofore," which he attributed to having moved the location of the canard elevator further forward.

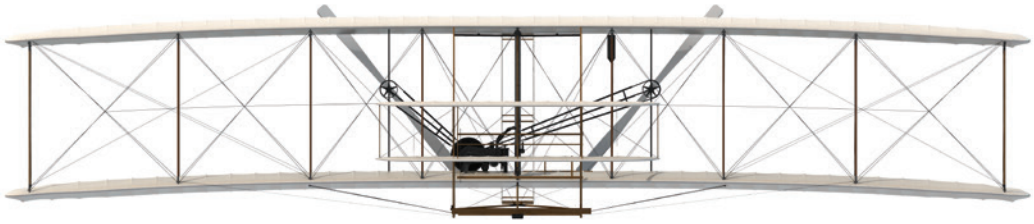
Meantime, they began assembly of their "Whopper Flying Machine." Their letters reveal how confident the brothers were, clearly knowing they had advanced beyond all other pioneers. That fall, Samuel Langley's understrength, overpowered, and woefully ill-considered Great Aerodrome failed in two launch attempts, first on October 8 (when it snagged its own catapult), and then on December 8 (when it broke up from its own structural weaknesses). "I see that Langley has had his fling, and failed," Orville wrote to Chanute after the October crash, adding, "It seems to be our turn to throw now, and I wonder what our luck will be."

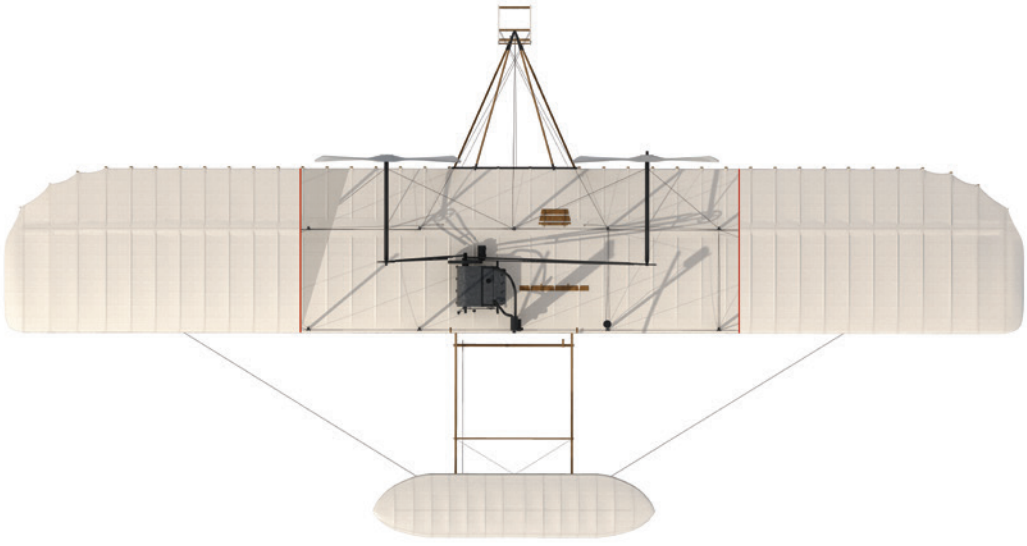
Even Chanute, visiting the Wrights at Kitty Hawk in November, did not appreciate how advanced the brothers were over their predecessors, tactlessly proposing that they test another of his multiplane gliders, and even, astonishingly, proposing that they test as well Clement Ader's *Avion III* – a twin-propeller steam-powered *Belle Époque* hopper looking like some grotesque bat from the mind of engraver Gustave Doré – that had skittered across the ground but otherwise failed to take to the air during trials at Satory in 1897. "He doesn't seem to think our machines are so much superior as the manner in which we handle them," Orville fumed in one letter home, noting, "We are of just the reverse opinion."

Over the fall of 1903 the Wrights finished assembly of the new Flyer and then readied it for first flight. Like many designers yet unborn, they found to their dismay that the Flyer was 75lb overweight, a deficiency fortunately offset by the propellers, which produced 50 percent greater thrust than anticipated. In the last weeks before first flight, the brothers tweaked engine performance to ensure smoothness of operation, and carefully adjusted the drive chains for the propellers. Problems with fracturing steel tube propeller shafts necessitated Orville returning to Dayton in late November and fabricating solid-steel ones. He did not return until December 11, after Langley's second crash (had he designed a stronger Great Aerodrome, this delay might have proven fatal to the brothers' hopes to be first in the air).

By mid-December the Wrights were ready to fly, for, unlike with their earlier kites, they had no desire to fly the 1903 Flyer initially as a kite. On December 14, following a coin toss, Wilbur attempted the first take-off, but over-controlled the sensitive canard elevator as he left the launch rail. The Flyer pitched up and stalled, settling relatively gently into the dunes 60ft ahead of the rail, though it did break some canard elevator supports. (Again, the canard configuration proved its value, for had he stalled and crashed a conventional design, it is likely it would have had to be completely rebuilt, and Wilbur Wright himself might have been seriously injured or even killed.) Repairs took two days, during which Wilbur telegraphed his father, reporting with characteristic forthrightness that a "Misjudgement at start reduced flight," and concluding with a prediction and a caution: "success assured keep quiet."

Then, on the morning of December 17, it was Orville's turn. That day, chilling winds gusting to 27mph blew across the dunes from the north, and the weather was bitterly cold. "The conditions were very unfavorable," Wilbur informed Chanute later, "as we had a cold gusty north wind blowing almost a gale." But the Wrights were in a race – would they be able to fly before having to return home for Christmas? An especially close family, the Wrights had a tradition of taking Christmas dinner together, and thus, in a very real sense, December 17 was their "make or break" day: make a flight, or break camp and return to Kitty Hawk the following year. They had placed the monorail track on a level stretch of sand about 200ft west of their buildings – a wise move subsequently helping establish their primacy in flight – and, with the help of volunteers from the life-saving station, the brothers placed the Flyer on the track.





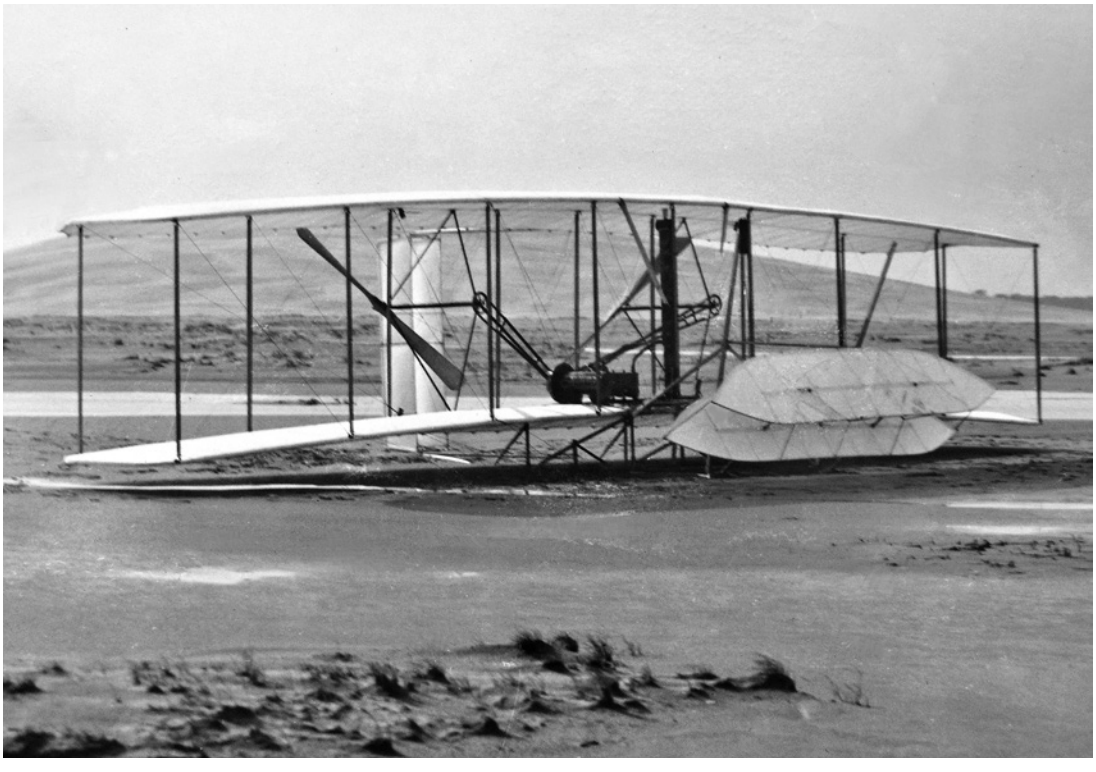
10.35am, December 17, 1903: Orville Wright takes off into the face of a 21mph wind, on the world's first powered, sustained, and controlled flight, remaining aloft for 12 seconds and covering 120ft. This iconic photograph (by John T. Daniels using Orville Wright's camera) captured the birth of the aerial age. (NASA)

Shortly after 10.30am, Orville lay down in the hip cradle, and started the engine with his right hand by moving a switch that opened a fuel cock. Wilbur then swung the right pusher propeller, and the engine fired immediately, settling into a steady rasping putter, the chain drive clicking over its sprockets and the twin propellers loudly thrumming. At 10.35am, Orville severed a tie-down rope, and the Flyer began to move. Wilbur ran alongside and steadied the right wing, as Orville carefully controlled the canard elevator with his left hand, steadying himself by gripping the leading edge of the wing with his right hand and bracing his feet against footrests. Besides Wilbur, six witnesses – including photographer John T. Daniels and Johnny Moore, a young boy from Nags Head – observed the flight.

Orville later wrote:

"The machine lifted from the track just as it was entering on the fourth rail [section]. Mr Daniels took a picture just as it left the tracks. I found the control of the front rudder [canard elevator] quite difficult on account of its being balanced too near the center and thus had a tendency to turn itself when started so that the rudder [elevator] was turned too far on one side and then too far on the other. As a result the machine would rise suddenly to about ten feet and then as suddenly, on turning the rudder [elevator] dart for the ground. A sudden dart when out about 100 feet from the end of the tracks ended the flight… This flight lasted only 12 seconds but it was nevertheless the first in the history of the world in which a machine carrying a man had raised itself by its own power into the air in full flight, had sailed forward without reduction of speed, and had finally landed at a point as high as that from which it started."

The Flyer had covered 120ft, and landed in generally good condition, though it had touched down hard enough to crack a front landing skid. Following speedy repairs to the skid and a control lever, the Wrights



At noon, on the fourth and last flight that day, Wilbur Wright remained aloft for 59 seconds and covered 852ft, but landed heavily, breaking the front elevator supports. Shortly after this photograph was taken, a violent gust of wind rolled the Flyer over and over, badly damaging it and ending further flight attempts. (LC)

returned to the air just 45 minutes after the first flight. At 11.20am, Wilbur took off on the second flight, covering approximately 175ft. At 11.40am, Orville made the third flight (and his second), matching's Wilbur's distance flown. Then, at noon, Wilbur took off on the fourth flight (and his second), remaining aloft for 59 seconds and covering 852ft. This time he landed heavily, breaking up the canard elevator's framing. After the brothers and their neighbors had carried the Flyer back to its shed, a sudden wind gust overturned it, rolling it over and catching photographer Daniels in the wreckage (fortunately without injury). It never flew again.

No matter, it had flown – repeatedly, under control, and in adverse, wind-buffeted, conditions. Without doubt, the brothers had conquered powered winged flight, beginning the era of the wind-defying aviator, and succeeding the era of the wind-constrained aeronaut. They had launched the aerial age, and later that day, Orville Wright sent his father the most significant message in aviation history, a telegram reading:

"Success four flights Thursday morning all against twenty one mile wind started from Level with engine power alone average speed through air thirty one miles longest 57 [sic] seconds inform Press home Christmas Orvevelle [sic] Wright"

Little Johnny Moore, however, best captured both the spirit and significance of the day. After the fourth flight, unable to contain his feelings any longer, he ran down the beach yelling at a friend, "They done it, they done it, damned if they ain't flew!"

CHAPTER FIVE

EVOLVING THE PRACTICAL AIRPLANE

THE FLYER II, FLYER III, AND MODEL A, 1904–1908

In 1904, the Wrights began flight tests of a new and slightly more powerful Flyer on Huffman Prairie, an 87-acre pasture east of Dayton. On September 20, 1904, piloted by Wilbur Wright, it completed the world's first circling flight by a heavier-than-air aircraft, witnessed (and subsequently memorialized) by Amos Root. (LC)

Orville Wright's "inform press" ensured news coverage of the brothers and their work. Their local paper, *The Dayton Daily News,* interviewed Bishop Wright and headlined its story: "Dayton Boys Emulate Great Santos-Dumont," referencing Brazil's Alberto Santos-Dumont, who had enthralled Paris with his small airships (and would soon do so again with Europe's first airplane). Pen-and-ink sketches of the two brothers, lauded as "Gem City Mechanics Who Built and Sailed the 'Wright Flyer'" (the latter name certainly better than "Whopper Flying Machine") illustrated the article. Other accounts followed in Norfolk's *Virginian Pilot*, the *Washington Post*, and Britain's *Daily Mail* (which hailed the "Balloonless Airship," noting, "The idea of the box kite was used in the construction").

But then publicity quickly died away – largely because the Wrights themselves reversed course in little more than a week after their triumph at Kitty Hawk. When, in late December, Octave Chanute sent Wilbur Wright a letter inviting him to speak before the annual meeting of the American Association for the Advancement of Science, Wilbur had telegraphed back, "We are giving no pictures nor descriptions of machine or methods at present."

Though the Wrights' turn-about dismayed Chanute (who communicated so freely that he often risked indiscretion), it made good sense. Their place in the history of flight was already secure. The

1903 Flyer had proven the brothers' various ideas, and having John Daniels snap a photograph of the first take-off had been inspired, for the image incontrovertibly established their primacy for all time. The flight results had been highly encouraging. "The machine possesses greater capacity of being controlled than any of our former machines," Wilbur had written to Chanute, adding, "One of the most gratifying features of the trials was the fact that all our calculations were shown to have worked out with absolute exactness so far as we can see."

Prudently, the Wrights had no desire to help would-be competitors copy and catch up. Already one had tried: Chanute's ex-helper Augustus Herring – hardly the Wrights' inventive coequal, though both ambitious and cunning – wrote to them immediately after their success at Kitty Hawk, proposing a partnership greatly benefiting him. Since first meeting Herring in 1902, the Wrights had never trusted him, finding him full of "schemes of rascality." Thus they did not respond, informing Chanute that they considered his old associate's bold overture a rank affront.

The Wrights decided as well to concentrate their flight test activities at Dayton. Through a friend, Torrence Huffman, they established a small test station with a catapult and assembly shed on an 87-acre field, located approximately 8½ miles east of their home. Known as Huffman Prairie and bordered by patchy woods, it was conveniently next to Simms Station on the Dayton transit line (today, fittingly, it is part of Wright-Patterson Air Force Base, home to Air Force Materiel Command), though the Wrights initially had problems with cattle and horses wandering about. Here, in mid-May 1904, the brothers began testing their next design, the so-called Flyer II.

THE WRIGHT FLYER II – THE FIRST CIRCLING AIRPLANE

Tested between May 26 and December 9, and generally similar to the 1903 Flyer, the 1904 machine nevertheless differed in many details, particularly in weight, as the brothers attempted to overcome deficiencies in longitudinal stability by using as much as 70lb of iron bars for ballasting. The 1904 Flyer had improved propulsion performance, thanks to a slightly more powerful engine, revised propeller design (giving improved thrust), and a changed sprocket ratio on the chain-drive (from a ratio of 2.875:1 to 3.3:1). It retained the prone-pilot layout of the Kitty Hawk Flyer that preceded it.

Its test program began with an ostensible failure that might actually have been a shrewd gambit for continued privacy. The brothers invited the press to witness their first flight attempt, but a combination of variable winds (too high, then too little) and engine trouble prevented them from flying. The press left in frustration, those few who returned the next day witnessing a short 60ft skimming hop with a sputtering engine. Afterwards the papers left the brothers unmolested over the next several years as they went about their flight trials. Whether the vagaries of fate or a clever ploy, the result was that the Wrights were able to work in virtual isolation.

To help the Flyer II get airborne, the Wrights used ever-longer launching tracks (up to 236ft in length), but by early August a series of nagging little accidents and the variability of winds caused them to invent a simple gravity-driven catapult to launch their future Flyers into the air. A 1,600lb weight attached to a cable hung from the apex of a simple 16ft derrick-like wooden tower. The cable, guided by a series of pulleys, ran down to the base of the tower, and then outwards under the launching track, to its end. It then doubled back above the track to an attachment point at the front of the Flyer. When the weight fell, it pulled the cable, accelerating the Flyer down the track and into the air in approximately 50ft. First used on September 7, 1904, the derrick catapult became synonymous with Wright flights over nearly the next decade.

As initially flown, the Flyer II had a persistent oscillatory longitudinal pitching motion as the pilot got out of phase with the inherently unstable airplane, which had an aft center-of-gravity (c.g.); this resulting in a bobbing flight and, sometimes, in an abrupt nosing into the ground. In a bid to cure it, and clearly not yet appreciating the implications of an aft c.g., the brothers shifted the engine even further aft on the wing which, of course, only made it worse. The brothers quickly moved the engine back forward, and even added ballast to the canard to shift the c.g. forward. Thus ballasted, the Flyer II flew much better, Amos Root (a genial bee-keeper who visited the brothers at Huffman Prairie and became a confident of theirs) reporting that "it was finally cured of its foolish tricks, [and] was made to go like a steady old horse."

Most notably, the Flyer II demonstrated the world's first controlled circling flight by a piloted airplane. On September 15, Wilbur Wright had made a half-circle, but gave up when it appeared the Flyer would pass beyond the area of Huffman Prairie. On the 20th, during his second flight that day (and the fourth attempt to circle), he completed a full circle. Root's account, appearing in the January 1905 edition of *Gleanings in Bee Culture*, was filled with wonder. "When it first turned that circle, and came near it was one of the grandest sights, if not the grandest sight, of my life," the bee-keeper recalled, thanking "God in His great mercy" for having permitted him to witness "an invention that may outrank electric cars, the automobiles, and all other methods of travel."

Beginning with their 1902 Glider, the Wrights had employed anhedral which worked to laterally and directionally destabilize their Flyers. The Flyer II had such problems that the brothers now realized they had to reduce the anhedral – eventually, they would eliminate it altogether – and its performance immediately improved, turning flights becoming commonplace. On November 9, for example, Wilbur Wright reported to Chanute that, "We went out to celebrate [President Theodore] Roosevelt's election by a long flight and went around four times in 5 min 4 sec."

Overall, then, the 1904 machine, very much an interim design, was nevertheless an important step forward for the Wrights as they sought to move their concept of the airplane from experiment to production. It accumulated a total flying time of approximately 50 minutes,

including two flights that each exceeded five minutes' duration. As was their fashion, the brothers scrapped it in 1905, salvaging the engine, propellers, and other fittings for their next design (the Flyer III of 1905), and then unceremoniously burning the wings and other structure.

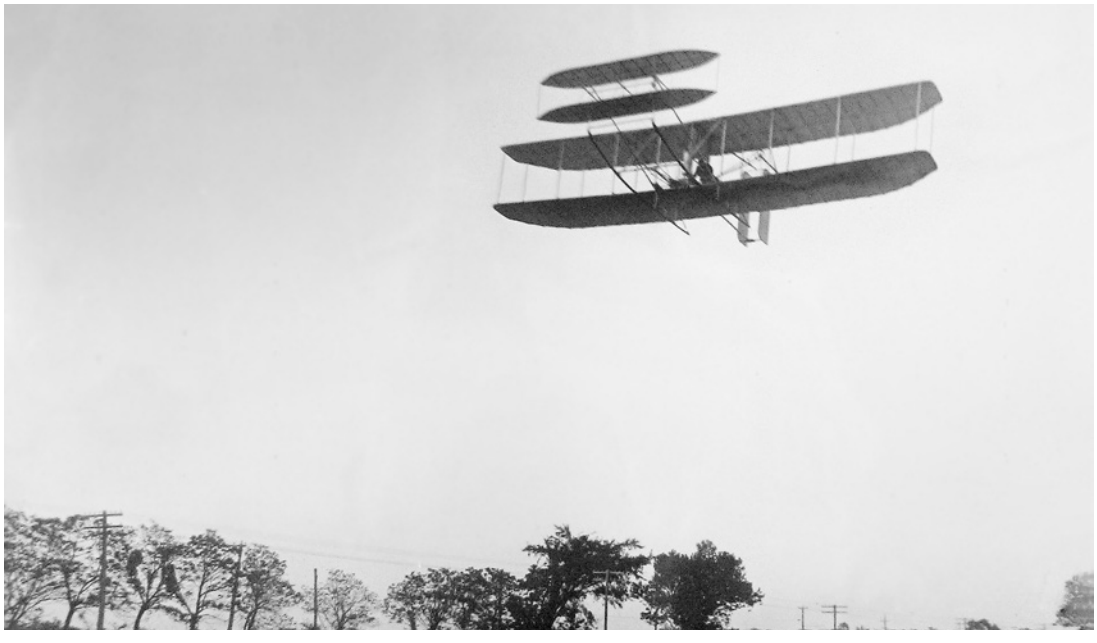
SPECIFICATIONS FOR THE WRIGHT 1904 FLYER II			
Wingspan	40ft 4in.	**Aerofoil camber**	1/25
Wing chord	6ft 6in.	**Canard biplane elevator area**	48sq ft
Wing gap	Approx. 6ft 2in.	**Vertical rudder area**	21sq ft
Length	21ft 1in.	**Weight (empty)**	Approx. 760lb
Height	Approx. 9ft 0in.	**Weight (gross)**	Approx. 900lb
Wing area	510sq ft	**Wing loading**	Approx. 1.76lb/sq ft
Structure:	Ash, spruce, wire, and muslin		
Engine:	One water-cooled four-cylinder 15–21hp horizontal inline of 214 cubic inch displacement running from 1,070rpm to 1,360rpm, weight/power 8.10lb/hp, bore and stroke 4⅛in. by 4in., chain-driving two contra-rotating ("handed") two-bladed propellers.		
Maximum speed:	Approximately 30mph		
Flight record:	80 total flights, approx. 50 minutes total flying time		

THE WRIGHT FLYER III – THE FIRST PRACTICAL AIRPLANE

In the early summer of 1905, the Wrights completed their third Flyer. While resembling the earlier 1903 and 1904 machines, it was, in fact, quite different, with a greatly strengthened structure, a higher stance on its skids, no anhedral (which improved its roll stability), reduced wing camber, a 7ft greater length that placed the canard elevator – which was almost 73 percent larger in area than previously – well ahead of the wing, dramatically improving longitudinal stability. It also had nearly 66 percent larger rudder, attached to a hinged rudder mount so that if the tail dragged the rudder would not be damaged or perhaps even torn from the machine.

The Wright 1905 Flyer was the first "practical" airplane, in that it was capable of repeated reuse. Much modified over its active life, which ran from 1905 through 1908, it was also the first Wright design to have independent three-axis control and upright seating for the pilot, though it was originally built both with the prone piloting position and interconnected warping and rudder controls similar to that employed on the 1903 and 1904 machines. The Flyer III had much improved longitudinal stability, thanks to dramatic changes in aircraft length and weight distribution. As a result, the estimated -20 percent static margin of the 1903–04 Flyers I and II reduced to approximately -8 percent, though the 1905 Flyer III was still an inherently unstable design. It made use of the launching catapult first used with the 1904 Flyer II.

Flown between late June and mid-October 1905, and then placed in storage, the Flyer III demonstrated extensive maneuverability including circles, figure-8s, and pronounced banking, all of which furnished evidence of the Wright brothers' growing mastery over



In 1905, the brothers flew the Wright Flyer III. Built with linked rudder and wing-warping, it was later modified with independent rudder and warping, making it the world's first three-axis controllable aircraft. On October 5, 1905, it remained aloft for 38 minutes, covering 24 miles while executing various circles and figure-8s over Huffman Prairie. The 1905 machine, preserved in Dayton's Carillon Historical Park, was the brothers' first practical and fully controllable Wright biplane, and thus the progenitor of all subsequent Wright civil and military pusher biplanes. (LC)

flight. Its rugged structure enabled repeated reuse. Its most notable flight was on October 5, when Wilbur Wright covered a distance of 24 miles in 39½ minutes, essentially performing a series of 30 continuous circles within the confines of Huffman Prairie, witnessed by nearly 20 onlookers, including a reporter and Bishop Wright.

On October 16, 1905, Wilbur Wright circled once over Huffman Prairie, remaining aloft just for one minute and 4⅗ seconds. Afterwards, the brothers put the 1905 Flyer III into storage. Incredibly, they then refrained from any flying for the next two-and-a-half years, while they worked to secure their patent rights and various international contracting opportunities. In 1908 they modified the Flyer III with independent three-axis controls – i.e. separate wing-warping, rudder, and elevator controls, so that roll, yaw, and pitch were independently controlled by the pilot employing separate control sticks (as discussed

SPECIFICATIONS FOR THE WRIGHT 1905 FLYER III			
Wingspan	40ft 6in.	**Aerofoil camber**	1/20
Wing chord	6ft 6in.	**Canard biplane elevator area**	83sq ft
Wing gap	5ft 11¼in.	**Vertical rudder area**	34.8sq ft
Length	28ft 0in.	**Weight (empty)**	Approx. 710lb
Height	Approx. 8ft 0in.	**Weight (gross)**	Approx. 850lb
Wing area	503sq ft	**Wing loading**	Approx. 1.69lb/sq ft
Structure:	Ash, spruce, wire, and unbleached cotton		
Engine:	One water-cooled four-cylinder 15–21hp horizontal inline of 214 cubic inch displacement running from 1,070rpm to 1,360rpm, weight/power 8.10lb/hp, bore and stroke 4⅛in. by 4in., chain-driving two contra-rotating ("handed") two-bladed propellers		
Maximum speed:	Approx. 36mph		
Flight record for 1905:	40 total flights, approx. 3 hr 40 min		
Flight record for 1908:	22 total flights, approx. 29 min 56 sec		

subsequently) – and two upright seats, making it the first airplane capable of carrying a passenger.

In this form the brothers flew it in May 1908 at Kitty Hawk (where the winds eliminated any need for the launching catapult), Wilbur taking it aloft on May 6 on an initial excursion that lasted just 22 seconds, covering 1,008ft. It was used as a "trainer" for their subsequent Fort Myer and European trials undertaken with other aircraft later that year. Badly damaged in an accident on May 14, 1908, the Flyer III was, fortunately, eventually restored and is exhibited at Carillon Park, Dayton, Ohio, as the world's second-most-historic airplane.

THE WRIGHT 1907 (WRIGHT MODEL A) FLYER – THE WORLD'S FIRST PRODUCTION AIRPLANE

The Wright Flyer III signaled that the brothers had passed from experimental to developmental design. The Flyer II had been only slightly more advanced than the Kitty Hawk Flyer (the Flyer I) that preceded it. But the Flyer III had all the elements of a pre-production airplane – a rugged structure, acceptable handling qualities (by the standards of the time), a proven and reliable propulsion system, and an assured means of launching it into the air. It had taken the brothers six years to reach this point, during which they had completed more than 120 powered flights, totaling only about six hours of flying time. Having accomplished so much, clearly the brothers were superlative airmen. The next step for the brothers was a production design they could offer in the growing aeronautical marketplace.

So, in 1907, the brothers embarked on a straightforward derivative of the 1905 Flyer III. Known to the Wrights as "our 1907 model," it constituted the first production airplane in world history – Lilienthal's earlier *Typ 11 Normal-Segelapparat*, though produced, had been a glider – and is usually referenced as the Wright Model A. It featured the side-by-side upright seating and independent yaw, pitch, and roll control of the modified 1905 Flyer III as flown in 1908. At least 11 Wright Model As were made between 1907 and 1910, seven in America and four others license-manufactured in France, and individual examples varied in their dimensions.

They also varied in their flight controls, reflecting differences between Wilbur and Orville on how the pilot should control the wing warping and rudder. Thus there were "Wilbur system" Model As and "Orville system" Model As. Both systems had three control sticks. The outermost sticks to the left of the pilot and right of the passenger controlled the elevator by pushing and pulling fore-and-aft, as with a modern control stick. The third stick between the two seats (to the right of the pilot, to the left of the passenger) differed according to which system was used. The Wilbur system had a pivoted stick that, when pushed or pulled fore and aft, turned the rudder left or right (today this is accomplished via rudder pedals). But the stick was also connected to a long rotational shaft so that, when the pilot rocked it laterally – that is, left or right – it warped the wings (similar to how a modern control stick operates roll-producing ailerons). The Orville system had a stick which, when pushed

forward or pulled aft, controlled the wing warping via cables from a half-disk affixed to its base. At the top of the stick was a pivoted handle that moved side-to-side to control the rudder via a rod that ran to a second full circular disk whose cables deflected the rudder. Depending on whether the pilot moved the stick and pivoted handle independently or together, the pilot could achieve either blended warping and rudder deflection, or independent control over either.

As Charles Gibbs-Smith, the greatest of all early flight historians, noted, neither system was ideal, for they both required counterintuitive stick displacement – fore-and-aft stick input for left-right rudder control or to roll left or roll right – and also kept both hands fully occupied.

Besides the Wrights and their company pilots, Model As were flown by other pioneers including Charles Comte de Lambert, Paul Tissandier, Mario Calderara (all Wright-trained in 1908–09), as well as Eugène Lefebvre (who perished in September 1909 in a French Wright built for Louis Schreck), and Marcel Baratoux. All used the launching catapult first employed on the 1904 Flyer II, though Schreck and Baratoux modified their Wright As to use wheels, flying them from Port-Aviation (the world's first specially built airport) at Juvisy, south of Paris.

Altogether, Model As completed hundreds of flights, with the Wright brothers alone making 452 of them. Today, only one still exists, a Dayton-built example shipped to Germany, where Orville flew it in 1909, as discussed in the following chapter. (Amazingly, it survived both civil discord and World War II, being exhibited at Munich's famed Deutsches Museum.)

SPECIFICATIONS FOR THE WRIGHT 1907 (WRIGHT MODEL A) FLYER			
Wingspan	41ft 0in.	**Aerofoil camber**	1/20 (est.)
Wing chord	6ft 6in.	**Canard biplane elevator area**	70sq ft
Wing gap	6ft 6in.	**Vertical rudder area**	23sq ft
Length	Approx. 31ft 0in.	**Weight (empty)**	Approx. 800lb
Height	Approx. 8ft 0in.	**Weight (gross)**	Approx. 1,100lb
Wing area	Approx. 510sq ft	**Wing loading**	Approx. 2.16lb/sq ft
Structure:	Ash, spruce, wire, and unbleached cotton		
Engine:	One water-cooled four-cylinder 28–42hp vertical inline of 240 cubic inch displacement running from 1,325rpm to 1,500rpm, weight/power 4.29lb/hp, bore and stroke 4⅜in. by 4in., chain-driving two contra-rotating ("handed") two-bladed propellers.		
Maximum speed:	Approx. 35mph		
Flight record for 1908:	139 total flights (125 in France and 14 in the US)		
Flight record for 1909:	219 total flights (67 in France, 58 in Italy, 35 in Germany, and 59 in the US)		
Flight record for 1910:	94 total flights (all in the US)		
Note:	Between August 8, 1908, and May 20, 1910, the Wrights completed 452 flights in Model As. Exact total flight time is impossible to compute as some data is missing, but is estimated at approximately 115 flight hours. Of these 452 flights, Orville flew 198 (163 in the US, 35 in Germany) and Wilbur flew 254 (192 in France, 58 in Italy, and 4 in the US). Orville likely would have flown many more but for his lengthy recuperation following his accident at Fort Myer, Virginia, on September 17, 1908, that killed Lt Thomas Selfridge (discussed subsequently). Numerous other pioneers flew them, and derivatives of them, as well.		

With the Model A, the Wrights had gone from being airplane inventors to budding industrial entrepreneurs. It was now time to take their invention public, onto the world stage.

CHAPTER SIX

"FLIERS OR LIARS"

In 1908–09, Wilbur Wright introduced Europe to the brothers' work. He began by flying from Hunaudières, a small race course south-southeast of Le Mans, on August 5, 1908. Here, his Model A Flyer is being readied for flight from the centre of the course, which today is remarkably unchanged. (LC)

THE WRIGHTS IN EUROPE, 1908–09

In 1902, Capt Ferdinand Ferber, a French army artillery officer and gliding enthusiast, had learned through the ever-talkative Octave Chanute of the Wright brothers and their gliding experiments. He immediately abandoned his experiments with a Lilienthal-style vehicle, adopted the Wrights' basic planform, contacted the brothers themselves the following year, and thereafter kept up a lively correspondence with them. As much as he admired them, he feared for the future of French aeronautics should they succeed.

In 1903, Octave Chanute briefed members of the Aéro-Club de France on his own work and that of the Wrights, afterwards publishing a detailed article in the journal *L'Aérophile*, complete with technical drawings of both his and the Wrights' gliders and tables of flight test data and relative efficiencies the brothers had obtained from flying their 1902 Glider the previous October. Their rapid progress surprised his hosts, who worried, like Ferber, that America might displace France as the pinnacle of global aeronautics. Subsequent accounts that the brothers had flown a powered airplane triggered further alarm. But then, as the brothers dropped from sight and French efforts to copy their gliders met with disappointment and failure, another school of thought arose: perhaps the Wrights were frauds.

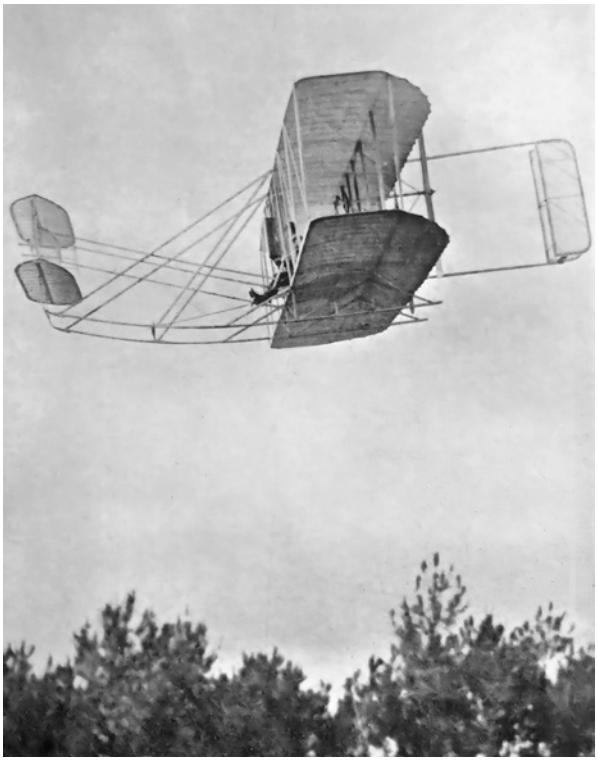
Over time, suspicion hardened into self-reassuring belief. In March 1905, Ernest Archdeacon, France's most prominent aeronautical personage, sent the brothers a sarcastic invitation "to come and give us lessons in France," a challenge the brothers found "rather amusing." That October, speaking before the recently created Fédération

Aéronautique Internationale, Archdeacon upped the ante, charging that the Wright accomplishments were "impossible to accept."

Thereafter the growing "*L'affaire Wright*" rapidly intensified, recalling the bitter partisan sniping attending the Dreyfus affair a decade earlier. The editors of the Paris edition of the *New York Herald* opined the Wright brothers were "either fliers or liars." The journal *L'Auto* even sent an investigator, Robert Coquelle – a professional bicycle racer – to poke about in Dayton. He subsequently wrote a four-part article for *L'Auto* entitled *"La Conquête de l'air par deux marchands de cycles"* [The conquest of the air by two bicycle dealers] that concluded, "It is impossible to doubt the success of their experiments."

On October 23, 1906, Alberto Santos-Dumont made a straight-line flight of about 200ft at an altitude of 10ft, flying a canard biplane called the *14-bis* before numerous witnesses. Archdeacon and others seized upon it as evidence of the innate superiority of French aeronautics. Over the next two years – and particularly in France – various individuals developed an assortment of pusher and tractor biplanes and monoplanes emphasizing stability, generous power, and large wing areas, their work eclipsing the secretive Wrights. When, in January 1908, designer-pilot Henri Farman completed a 1km (0.62 mile) circle and a prize-winning 1.5km (0.93 mile) distance flight at Issy-les-Moulineaux, Archdeacon hailed his having "first and incontestably won mastery of the air in an airplane," and the London *Times* proclaimed: "The Conquest of the Air."

Later that summer, two French airmen – Léon Delagrange and Henri Farman – took their airplanes abroad, becoming the world's first airshow pilots (though their exhibitions featured hops and ground-skimming rather than true flights). That summer, Delagrange visited Rome, Milan, and Turin, taking sculptress Thérèse Peltier aloft in the latter city (she thus became the first woman ever to ride in an airplane). Farman went to Ghent, in Belgium, and then on to Brighton Beach, New York, where, alas, bouts of rain and wind constrained his performances.



Wilbur Wright descends low over the Hunaudières course; note the deflected front elevator. The evident ease with which he controlled his flights stunned onlookers and revolutionized European aeronautics. In less than a year, French aviators and designers matched, and then quickly surpassed, the Wrights. (RPH)

"WE ARE AS CHILDREN COMPARED TO THE WRIGHTS"

The Wrights had received numerous overtures from foreign governments and emissaries, and in May 1907 Wilbur left for Europe (joined subsequently by Orville) on an extended business trip to negotiate with British, French, and German representatives regarding rights to the brothers' invention and possible production licensing agreements, during which the brothers had crated and shipped a

Model A to France, placing it in storage when negotiations for a French contract at that time fell apart.

As discussed in the next chapter, as a result of negotiations with the US War Department, the brothers secured an Army Signal Corps contract on February 10, 1908, for a military Flyer. Then, on March 23, the brothers received another bit of good news: a French syndicate headed by Lazare Weiller agreed to the brothers' terms for purchasing patent rights and production license rights. Recognizing that they needed to refresh their dormant flying skills, the brothers shipped the modified 1905 Flyer III from Dayton to Kitty Hawk, where, beginning on May 6, they completed 22 flights, several witnessed by journalists including reporters from Britain's *Daily Mail*, the *New York Herald*, and *Collier's Weekly*. Twice on May 14, Wilbur flew with mechanic Charles W. "Charley" Furnas, who thus became the first passenger ever to fly in an airplane. Unfortunately, on the third flight that day the Flyer III, pushed by a tailwind to over 50mph, suddenly plunged into the ground, fortuitously without seriously injuring Wilbur Wright.

Though the brothers had hoped to go first to France and then come back to America and exhibit their military Flyer, by the late spring they realized both needed to be done simultaneously. A week after

NEXT PAGES

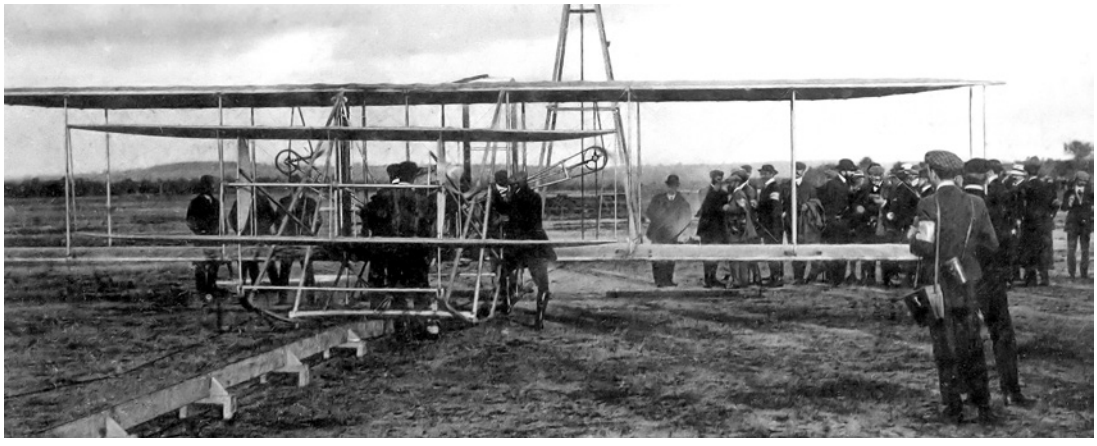
WILBUR WRIGHT IN EUROPE

At 6.30pm on Saturday, August 8, 1908, before several hundred onlookers, Wilbur Wright catapulted aloft from the eastern infield of the Hunaudières race course 5 miles south-southeast of Le Mans. He immediately rolled into a sharply banked left turn, ascending steeply into a broad climbing circle over the race course, stunning the aviators scattered through the crowd. At approximately 100ft in altitude, he leveled off into a second circle, again showing off the perfect control the two brothers had achieved, and, after completing it, dipped into a gentle curving descent (shown here), landing (as one French observer noted) "with the ease and grace of a wood pigeon." His flight covered 2.17 miles (3.5km) in 1 minute and 45 seconds, prompting aviator Louis Blériot to exclaim, "I would have waited ten times as long to see what I have seen today," adding, "Monsieur Wright has us all in his hands."

Spurred by news accounts, thousands of curious enthusiasts ventured to Hunaudières the following Monday, their curiosity rewarded by two flights during which Wright executed an unusually tight circle with a diameter of just 93ft (28m), followed by a figure-8 that electrified those watching the astonishing display. *L'Aérophile,* France's leading aeronautical journal, reported: "The ease with which the machine flies and the dexterity of the aviator in his maneuvering has dissipated all doubts. None of the old Wright detractors can question today the previous achievements of these men who were truly the first to fly."

"The newspapers and the French aviators nearly went wild with excitement," Wilbur wrote to his brother Orville (then preparing to leave Dayton for Fort Myer, Virginia, and the first demonstrations of the Wright machine to the US Army Signal Corps) on August 15, adding, "You never saw anything like the reversal of position that took place after two or three little flights of less than two minutes each."

But the Wrights' obvious mastery of flight discouraged some witnessing the Flyer's pirouetting over Hunaudières. "*Eh bien,*" Léon Delagrange exclaimed, "we are beaten; we just don't exist." His colleague René Gasnier morosely exclaimed, "We are as children compared with the Wrights." Over the next two years, however, French aviators, starting with Louis Bleriot's crossing the Channel in July 1909, would match and then rapidly surpass the Wrights, restoring the aeronautical primacy Europe had lost following the failures of Ader and Maxim and the deaths of Otto Lilienthal and Percy Pilcher.



After nine flights, Wilbur Wright moved from Hunaudières to a more spacious artillery training range at Camp d'Auvours, east of Le Mans. Here the Flyer is on its launch rail with the catapult derrick, though, on at least one flight, Wilbur Wright simply flew off the rail without resort to the catapult. (LC)

his accident, Wilbur sailed for France. Orville remained in the US to conduct the demonstration flights for the Signal Corps at Fort Myer, Virginia.

When Wilbur arrived in France he found French aviation enthusiasts both friendly and helpful (Louis Blériot, for example, offered him use of a workshop, and Ferdinand Ferber greeted him with almost worshipful emotion). Overall, however, there was a sense of great curiosity. Working out of factory space at Le Mans, Wilbur discovered to his shock that the 1907 Flyer was in dreadful shape – overzealous French customs inspectors had left it carelessly repacked, with many broken ribs, torn cloth, smashed radiators, and other damaged components. "I never saw such evidences of idiocy in my life," he fumed to Orville, whom he had initially and unfairly blamed before discovering the truth.

Finally, late on the afternoon of August 8, 1908, he was ready to fly, from Hunaudières race track. Located not quite 5 miles south-southeast of Le Mans, it was a turf oval measuring 2,625ft by 984ft, bordered by thin woods including brush and young trees within the center grounds of the track. A galaxy of French aviators and advocates assembled along the track fence, including the Aéro Club's Ernest Archdeacon, Louis Blériot, and René Gasnier, joined by the Wrights' European representative, Hart O. Berg of Flint and Company.

At approximately 6.30pm, Wilbur Wright started the engine, the Flyer taking off "like an arrow from a crossbow," looking in the summer sun like a "great white bird." Rolling into a steep bank – something unthinkable in any other airplane of the day – he completed two circuits of the field in 1 minute and 45 seconds, rolling out wings-level and landing "with the ease and grace of a wood pigeon."

Two days later he flew twice, performing two large figure-8s, this time before a crowd of 2,000, including journalists, French aviator Léon Delagrange, and the American balloonist-adventurer Frank S. Lahm, the European representative of the Remington Typewriter Company, whose son Frank P. Lahm, himself a balloonist, played a crucial role in bringing the Wrights to the favorable attention of the US War Department. The sight of Wilbur casually pirouetting through the air over Hunaudières

On October 7, 1908, Wilbur Wright flew Edith Berg, the wife of Hart O. Berg, his European business manager, at Camp d'Auvours, making her the first American woman ever to fly in an airplane. Note the rope she used to tie the bottom of her skirt, later credited with inspiring the so-called "hobble skirt." (LC)

race course recalled the *annus mirabilis,* the "miraculous year" when Pilâtre de Rozier, the Marquis d'Arlandes, J. A. C. Charles, and Noël Robert flew their first balloons over Paris not quite 125 years previously. "Who can now doubt that the Wrights have done all that they claimed?" René Gasnier asked rhetorically, adding, "We are as children compared to the Wrights."

On August 13, by which time thousands had seen him fly, Wilbur experienced a minor landing accident at the end of his ninth flight that grounded the Flyer for repairs. He used the opportunity to move to a larger and more suitable field, on an artillery range at d'Auvours, east of Le Mans. He resumed flying on August 21, and thereafter steadily increased his flight durations. To onlookers who, had they even seen an airplane fly, had counted its flight time in seconds, the flights of Wilbur Wright seemed the stuff of wishful fiction. On September 3 he flew for 10 minutes and 40 seconds. Two days later he extended this to 19 minutes and 48⅖ seconds. On September 21 he remained aloft for 1 hour, 31 minutes and 25⅘ seconds, as a crowd of 10,000 watched. Finally, on the last day of the year and his 124th flight in France, he flew an incredible 2 hours, 20 minutes and 23⅕ seconds, braving an icy mist to win the 20,000-franc Michelin Cup (then US$4,000, equivalent to US$110,000, £87,000, or €98,000 in 2019) and a smaller 500-franc prize.

Wright's flights attracted great attention from the international aviation community and other notables, and over the fall of 1908 he flew many of them. Just a partial listing includes:

- America's Hart O. Berg and his wife Edith (the first American woman to fly in an airplane), George Dickin (of the *New York Herald,* the world's first journalist to fly in an airplane), and Frank S. Lahm;
- Britain's Griffith Brewer (first Briton to fly), Charles S. Rolls (co-founder of Rolls-Royce), and B. F. S. Baden-Powell (president of the Aeronautical Society of Great Britain, now the Royal Aeronautical Society);
- France's René Gasnier, the Comte de Lambert, Paul Lucas-Girardville, Henri Deutsch de la Meurthe, Paul Panlevé, Frantz Reichel (of *Le Figaro),* Paul Tissandier, and Ernest Zens.

These flights and the stature of those who witnessed them (and in some cases experienced them) – assembled royalty, politicians, military figures, industrialists, bankers, educators, and others – ensured that, from 1908 onwards, aviation, and the prospects of aviation, were considered with a gravitas and acceptance unthinkable just a decade earlier, when even a scientist such as Britain's Lord Kelvin could write (rejecting Baden-Powell's generous offer to him of membership in the Aeronautical Society of Great Britain), "I have not the smallest molecule of faith in aerial

navigation other than ballooning." They also stimulated others to enter the aviation field. After Wilbur Wright flew in France in 1908, for example, Sir Geoffrey de Havilland "knew at once … this was the machine to which I was prepared to give my life."

In January 1909, Wright moved his flying location yet again, to Pont-Long, east of Pau in southwest France, near the Piedmont of the Pyrenees, where he was joined by Orville (recuperating from his crash at Fort Myer the previous September) and his sister Katharine. There, from February 3 until March 20, he made a further 67 flights, training student pilots (de Lambert, Lucas-Girardville, and Tissandier), flying various passengers (including de Lambert's wife and his own sister Katharine, whom he flew for over 7 minutes on February 15), and generally introducing many other notables to aeronautics.

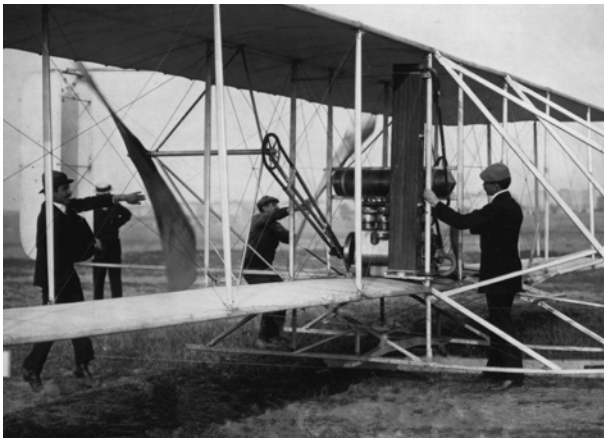
In January 1909, after completing 115 flights at d'Auvours (and one at Toury), Wilbur moved his flight operations to Pont-Long, east of Pau in southwest France. Over two-and-a-half months he made a further 67 flights and trained several aviators, flew some passengers, and briefed many dignitaries, including young King Alfonso XIII of Spain, shown here. (LC)

The warmth of French reaction to his flights, following the frosty allegations of the now-utterly discredited *L'affaire Wright*, touched Wilbur Wright deeply, evident in his remarks before the Aéro Club de France at a banquet on November 5, 1908, held in the brothers' honor. "I have been received in France with a friendliness scarcely to be realized," he said, adding, "When we did not know each other, we had no confidence in each other; today, when we are acquainted, it is otherwise: we believe in each other, and we are friends."

In early April, Wilbur Wright left France for Italy. There, over the course of 58 flights from April 15 to 27, he carried 19 passengers and trained two pilots – naval Lt Mario Calderara and army Lt Umberto Savoia – three of his flights witnessed by King Victor Emmanuel III. All his flights were made at Centocelle, southeast of Rome, which subsequently became Italy's first military flying school. Afterwards, he, his brother, and sister returned to the States, stopping briefly in Britain – for just two days – where, at Mussel Manor at Shellbeach on the Isle of Sheppey, they renewed their acquaintanceship with J. T. C. Moore-Brabazon (holder of the Royal Aero Club's first aviator's certificate), Griffith Brewer (their British agent), Charles Rolls, Alfred Harmsworth (Lord Northcliffe, the influential founder of the aviation-prize-offering *Daily Mail*), and other British aviation notables. That done, they embarked on the North German Lloyd liner *Kronprinzessin Cecilie*, arriving in New York on May 11 to a series of delirious receptions.

Among his passengers was his sister Katharine, shown shortly before her first flight, on February 15, 1909, a brief 7-minute 4-second excursion. Note the use of the "Wilbur" flight control system. (LC)

However, the Wrights were not yet done with Europe for the year. While Wilbur Wright took a break after his intensive flying over the previous 12 months, his brother Orville, now recovered, went to Fort Myer in late June for a month of trials of the brothers' new military airplane



In late August 1909, Orville Wright went to Germany. Over the next month he made 19 flights at Berlin's Tempelhof field. Here his airplane is shown being readied for flight at Tempelhof, later the greatest of all German airports. Just visible in front of the lower wing leading edge to the right of Orville's right hip is the tell-tale disk controlling the rudder cables, characteristic of all "Orville system" airplanes. This particular Flyer is now preserved at the Deutsches Museum, Munich. (LC)

(as discussed subsequently). When these concluded successfully at the end of July, he and Katharine prepared for a near-immediate departure for Germany, leaving New York on August 10 – again on the *Kronprinzessin Cecilie* – somewhat distracted by a growing legal squabble over patent infringement with fellow pioneer Glenn Curtiss that would soon erupt into open warfare.

Months previously, a group of German businessmen had entered into a partnership with the Wrights, forming Flugmaschine Wright GmbH. After Lilienthal's death, winged aeronautics in Germany had largely stagnated – the Wrights were about to fix that – in favor of aerostatics, the science and technology of rigid and non-rigid airships. Thus, when the Wrights arrived in Germany, their hosts spared no effort to make them feel welcome, flying Orville on the German Zeppelin *LZ-5* and his sister Katharine in a Parseval blimp.

Orville Wright's subsequent flights in Germany replicated Wilbur's experiences in France and Italy, but on a smaller scale. Between August 30 and September 18, he made 19 flights at Berlin's Tempelhof parade ground, his flights witnessed by not only the military, industrial, and governmental elite of the Kaiser's Germany – among whom were Crown Prince Wilhelm and his wife, the Princess Cecilie, and Generaloberst Helmuth Graf von Moltke, chief of the Great General Staff – but many ordinary German citizens as well. Indeed on September 9, an estimated 200,000 witnessed him flying. On September 17, he climbed to an altitude of approximately 565ft, one royal observer recording in her diary that, "the [onlooker's] heart stands still at the shock!" The next day he set a duration record for a flight with a passenger (retired German naval Capt Paul Engelhard, a Wright student) of 1 hour, 35 minutes and 46 seconds.

In late September, Orville relocated to the Bornstedt drilling grounds at Potsdam, where he flew another 16 flights. On one of these, made on October 2, he flew Crown Prince Wilhelm on a 15-minute flight at about 100ft, after which the Crown Prince presented him with a gold tiepin with his initial "W" in rubies and diamonds. Orville's last flight, on October 15, was witnessed by Kaiser Wilhelm, his wife the Empress, and assorted other royals. Altogether, Orville Wright had completed 35 flights in Germany, doing much to rebirth winged aviation in that country, and his prized pupil, Capt Engelhard, had soloed before he left. Orville and Katharine Wright returned home in early November aboard the White Star liner *Adriatic* after having had "a splendid time in Germany."

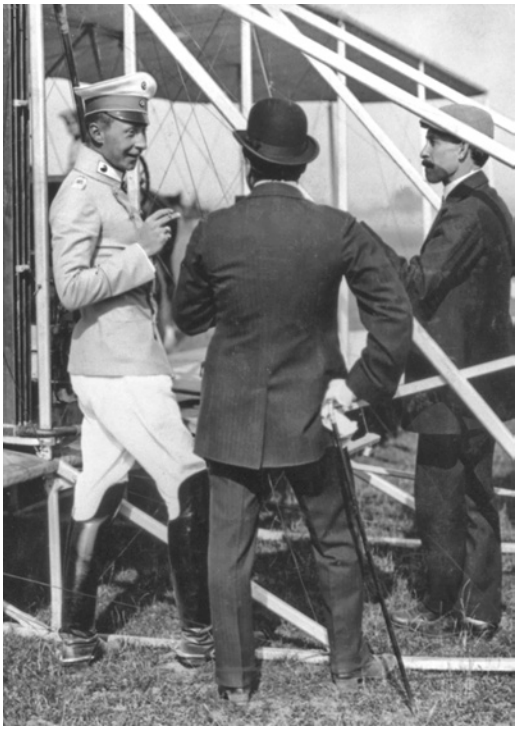
"THE AGE OF FLIGHT IS THE AGE WE LIVE IN"

The years 1908–09 represented the apogee of Wright fortunes in aeronautics, and the vehicle of that success had been the Model A. It introduced the Western world to winged flight via the brothers'

exhibitions over 1908–10 in Europe and America. "All of the flights made by Wilbur in France and Italy and at Governors Island in 1908 and 1909, and by me at Fort Myer in 1908, at Berlin and Potsdam in 1909, and at Montgomery, Alabama, in 1910, were made with this 1907 model," Orville Wright recalled nearly 40 years after the type's first flights, this alone sufficient to make it an aircraft type of singular importance to aviation history.

But by the time Orville and Katharine Wright had returned from Germany, European aviation, too long dormant, was on the move. Louis Blériot had crossed the Channel – something the Wrights could have done, but chose not to – on July 25, 1909, in his monoplane Model XI, pulled along by an Anzani three-cylinder engine and a highly efficient propeller designed by Lucien Chauvière; the next day, Lord Northcliffe's *Daily Mail* boldly proclaimed to its readers: "England is no longer an island."

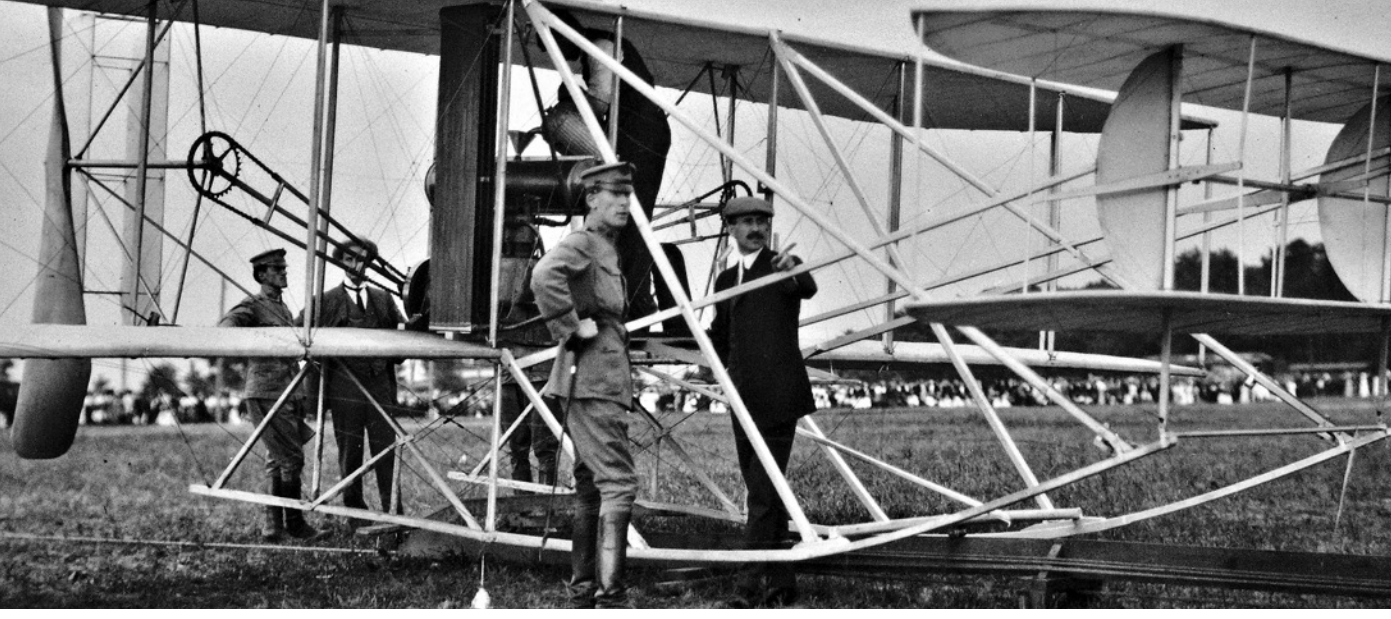
A month later, half a million visitors attended Reims' Grande Semaine d'Aviation, a week-long celebration of races and exhibitions that showcased new French monoplanes such as the Blériot, Antoinette, and REP; Farman and Voisin biplanes; and the Séguin brothers' ingenious seven-cylinder 50hp Gnôme rotary engine, as revolutionary for engine technology as the Wright Kitty Hawk Flyer had been for airplanes. Though foreign Wright Type As flew, the Wrights themselves did not. Indeed, the only American who did fly was their emergent rival, Glenn Curtiss, who won two speed contests. A month after Reims, France held another exhibition, this one in Paris' Grand Palais, again showcasing French designs, with a lone Wright Flyer "tucked away" in an upstairs loft.



Not quite a month after arriving in Germany, Orville moved his flying operations to Potsdam's Bornstedt drilling grounds, completing a further 16 flights. Among those who flew with him at Bornstedt was Crown Prince Wilhelm (left), shown talking to Orville Wright (right) and Hart O. Berg (centre, with back to camera). Orville's "beard" is actually a shadow from the Flyer's upper wing. (LC)

As 1909 closed, aviation had already progressed from the purely experimental stage to that of practical development and application. Humanity could, at will, move through the air as easily as it moved across the sea or on land. After Reims, none could doubt otherwise. "The Reims meeting marks an epoch in the history of mechanical aerial locomotion," proclaimed Britain's *Flight* magazine, adding, "none who read can doubt any longer. The age of flight is the age we live in." But if the brothers Wright had brought flight to the world, they no longer controlled it, as others introduced newer generations of more advanced designs that would soon supplant theirs.

The Wrights themselves had also reached a momentous decision, as Wilbur informed Chanute on December 6. "We have closed out our American business to the Wright Company," he said. "We received a very satisfactory cash payment, forty percent of the stock, and are to receive a royalty on every machine built in addition. The general supervision of the business will be in our hands though a general manager will be secured to directly have charge. We will devote most of our time to experimental work."



CHAPTER SEVEN

BIRTHING MILITARY AERONAUTICS

Here Orville Wright and Lt Frank Lahm prepare for the first official test of the Military Flyer on July 27, 1909, during which the two set an endurance record of 1 hour, 12 minutes and 40 seconds. Lahm became the world's first rated military airplane pilot, and an influential officer who introduced military aviation into the Philippines. (LC)

THE WRIGHTS' SIGNAL CORPS AND NAVY BIPLANES, 1908–1914

While in France in 1907, the Wright brothers had met an enthusiastic young balloonist, Lt Frank P. Lahm, who shared their passion for flight. A believer in airplanes, he urged his superiors to give the Wrights a hearing. So, too, did an Aero Club of America delegation, appealing to President Theodore Roosevelt. "TR" deferred to his Secretary of War, who asked the Board of Ordnance and Fortification (which previously rebuffed the Wrights) to investigate.

On December 5, 1907, Wilbur Wright met with the Board, offering to furnish a two-man 40mph Flyer for $25,000 USD ($680,000 USD in 2019). Impressed, Brig Gen James Allen, the Army's Chief Signal Officer, issued Signal Corps Specification No. 486 on December 23, tailored to the Wrights. Though 41 bidders replied by the February 1, 1908, deadline, only the brothers had a realistic proposal. Thus, on February 10, 1908, the Signal Corps awarded them the contract, stipulating that their airplane should attain 40mph (and no less than 36mph), have a range of 125 miles, be capable of landing, servicing, and returning to flight within an hour, and carry a pilot and observer. The completed aircraft would be evaluated at Fort Myer, Virginia, on the western bluffs of the Potomac River, directly across from Washington, D.C.

Tragedy struck on the late afternoon of September 17, 1908, when the Flyer's right propeller partially fractured, setting up an unequal thrust and consequent vibration so that the undamaged left propeller came into contact with and severed a rudder wire, sending the Flyer plunging to earth. The crash badly injured Orville Wright and mortally injured his passenger, Army Lt Thomas Selfridge, who had worked with Alexander Graham Bell in the short-lived but influential Aerial Experiment Association. (NMUSAF)

THE FORT MYER TRIALS

The 1908 Military Flyer Orville Wright demonstrated at Fort Myer in September 1908 was basically the Model A with an "Orville" control system. Accompanied by Charles Taylor and Charles Furnas, he delivered it to Fort Myer on August 20, making its first flight on September 3, a short 1-minute 11-second circuit. On September 9, he made two flights, one of 57 minutes 31 seconds and a second of 62 minutes 15 seconds, successive world records, followed by a 6-minute 24-second flight with Lt Lahm, who became the first American military officer to fly in an airplane. On September 12, Orville remained aloft for 1 hour, 14 minutes and 20 seconds, making 71 circuits over Fort Myer.

Winds prevented flying over the next three days. Then, on September 17, Orville went aloft accompanied by Army Lt Thomas Selfridge. Scion of a distinguished military family, he had worked with Alexander Graham Bell's Aerial Experiment Association (AEA) in Nova Scotia, riding *Cygnet I* (a giant tetrahedral kite), designing the AEA's first airplane (the *Red Wing*), flying its second (the *White Wing*) and also its third (Glenn Curtiss's *June Bug*).

The Flyer had completed three circuits when Orville heard a "light tapping" then "two big thumps, which gave the machine a terrible shaking." The right propeller had cracked, triggering vibrations so violent that the undamaged left propeller severed a wildly oscillating rudder wire. Beyond control, the Flyer plunged to earth, mortally injuring Selfridge, who died several hours later. Wright, though less seriously injured, still required two months' hospitalization.

In June 1909, the Wrights returned to Fort Myer with a new design, their Signal

In 1909, though not yet completely recovered from his accident, Orville Wright returned to Fort Myer with a new Military Flyer that had a reduced wing area, a taller undercarriage, and a higher speed of 45mph. Here it is flying low over the Fort Myer parade ground. The world's first military airplane, it subsequently became an important pilot trainer for Army airmen. (LC)

Corps Flyer, the world's first airplane accepted into military service. Smaller and heavier than previous Wright designs, it was faster and had better flying characteristics. Despite wheels on new European designs, it still relied on catapult launch and landing skids. Placed between the upper and lower canard elevator surfaces were half-moon vertical surfaces (which the Wrights called "blinkers") for additional directional stability.

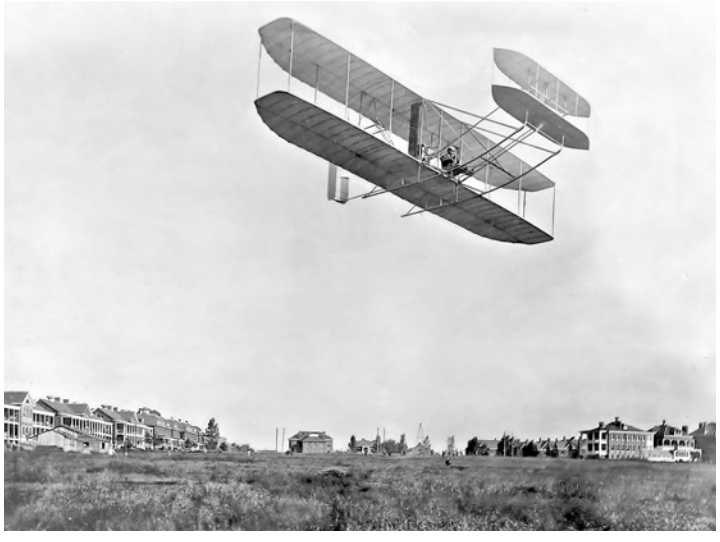
SPECIFICATIONS FOR THE WRIGHT 1909 SIGNAL CORPS FLYER			
Wingspan	36ft 6in.	**Aerofoil camber**	1/20
Wing chord	5ft 10in.	**Canard biplane elevator area**	80sq ft
Wing gap	5ft 0in.	**Vertical rudder area**	16sq ft
Length	Approx. 28ft 11in.	**Weight (empty)**	735lb
Height	Approx. 8ft 0in.	**Weight (gross, with pilot and observer)**	Approx. 1,200lb
Wing area	Approx. 415sq ft	**Wing loading**	Approx. 2.89lb/sq ft
Structure:	Ash, spruce, wire, and unbleached cotton		
Engine:	One water-cooled Wright four-cylinder 32hp vertical inline running at 1,310rpm, chain-driving two contra-rotating ("handed") two-bladed propellers; engine weight approx. 4.29lb/hp; bore and stroke, 4⅜in x 4 in.		
Maximum speed:	44mph		
Flight record for 1909:	At least 23 at Fort Myer; College Park unknown		
Flight record for 1910:	64 flights at Fort Sam Houston, Texas		

Orville Wright completed its first flights on June 29. On July 20, he remained aloft for 1 hour, 20 minutes and 45 seconds, performing figure-8s and circling the field 83 times at 300ft. On July 26, President William Howard Taft witnessed a short flight. On July 27, Orville flew with Lahm for 1 hour, 12 minutes and 40 seconds, fulfilling a requirement to demonstrate a 1-hour flight with a passenger. Three days later, on July 30, Lt Benjamin D. Foulois (a future Army Air Corps chief of staff) accompanied Orville on a speed test. They flew 5.2 miles to Shooters Hill (now the site of a towering Masonic temple) at Alexandria, Virginia, returning in 14 minutes 40 seconds, having averaged 42.58mph, and winning a performance bonus. The flight – Orville's 23rd in the 1909 Flyer – concluded the Army's trials. On August 2, 1909, the Signal Corps paid the brothers $30,000 (approximately $830,000 in 2019), representing the price of $25,000 plus $5,000 for the bonus.

The Wright flights always attracted large and enthusiastic crowds, including numerous officials and other dignitaries, and the 1909 Fort Myer trials were no different. On July 26, US President William Howard Taft (right, standing in background with straw hat inside shed) visited Fort Myer and witnessed Orville making a short 2-minute 20-second flight. (LC)

TRAINING AIRMEN AND EXPLORING MISSIONS

The parade ground at Fort Myer was too small for training, so Lt Frank Lahm selected an open field at College Park, near the Maryland Agricultural College (now the main campus of the University of Maryland), the birth of what is now the world's oldest continually operating airport. There, flying a Model A over October and November 1909, Wilbur Wright taught Lahm and Lt Frederic Humphreys to fly (both soloed on October 26).



In September 1908, Orville Wright demonstrated a Wright Flyer A designed in response to a US Army Signal Corps specification at Fort Myer, Virginia. Here it is shown circling over the post's parade ground. In the centre, directly under the Flyer, is the framework of the catapult's launch derrick. On September 9, he flew Lt Frank Lahm, who thus became the first military airman to fly in an airplane. (NMUSAF)

Wright left in early November (after 55 solo and instructional flights), Lahm and Humphreys serving as instructors. On November 3, Lahm flew Lt George C. Sweet USN, making him the first naval officer to fly in an airplane. The Army then temporarily relocated its flying to the calmer, warmer climes of Fort Sam Houston at San Antonio, Texas.

Following establishment of the Wright Flying School at Simms Station in early 1910, the Army and Navy sent officers to train with the Wrights and their pilots, two notable students being Lt Henry H. "Hap" Arnold (later chief of staff of the US Army Air Forces) and Lt John Rodgers USN (who rose high in the Navy's Bureau of Aeronautics, but died in an accident). Arnold remembered his fellow students, instructor Al Welsh, and the Wrights fondly. "More than anyone I have ever known or read about," Arnold wrote shortly before his own death, "the Wright brothers gave me the sense that nothing is impossible."

The balloon had revolutionized battlefield observation and artillery spotting, and the airplane promised to do even more. In February 1910, Lt Benjamin Foulois and a small team arrived at Fort Sam Houston with the 1909 Flyer, now designated Signal Corps No. 1 (S.C. 1). "Your orders are simple," Gen Allen had told him. "You are to evaluate the aeroplane. Just take plenty of spare parts – and teach yourself to fly." Foulois and S.C. 1 completed 64 flights between February through October 1910, experimenting with both major and minor changes to its configuration, including removing the top surface from the canard elevator and relocating it behind the tail boom as a stabilizing surface, adding a wheeled undercarriage – a first, for the Wrights did not display a similar wheeled undercarriage until August 1910 – and changing its flight control system to that used by the newer Model B. By early 1911, it was worn out; the Army returning it to the Wrights, who restored it and then donated it to the Smithsonian Institution, where it is still exhibited, the antecedent of all military airplanes.

One of the earliest Wright pupils was Army Lt Henry H. "Hap" Arnold, shown here while learning to fly at the Wright school at Simms Station, Ohio, in May 1911, in a Flyer with the "Orville"-style flight control system. Arnold subsequently served as Chief of Staff of the Army Air Forces during World War II and was the principal architect of the postwar US Air Force. (NMUSAF)

On May 21, 1910, Orville Wright completed the initial flight of the Model B, flying it for 18 minutes 35 seconds and attaining an altitude of 2,000ft. As the 1903 Flyer established a standard for Wright canard designs, the Model B initiated a new standard lasting through Wilbur's life – he died in May 1912 – and Orville's tenure with the company (he left in 1915). It reflected two realities: the inherently unstable canard biplane configuration was outdated, and catapult launch was an unnecessary liability.

The Model B – also license-produced (but with a different engine) as the Burgess F by the W. Starling Burgess Company of Marblehead, Massachusetts – had its elevator behind the wing and aft of the vertical rudder, the front framing of the machine furnishing only protective structure and bracing for the skids (which were themselves shortened), and supporting two distinctive triangular-shaped vertical finlets for added directional stability. Though it retained the same wing and layout – side-by-side seats on the leading edge, and an engine chain-driving two pusher propellers – it had a greatly lengthened tail boom. With its center of gravity now ahead of the airplane's neutral point, the Model B was the Wrights' first inherently stable machine, eliminating the characteristic bobbing-and-weaving of its predecessors. As well, the Model B abandoned the catapult, incorporating a wheeled undercarriage for routine operation.

SPECIFICATIONS FOR THE WRIGHT MODEL B FLYER (BURGESS F DATA IN BRACKETS)			
Wingspan	39ft 0in. (39ft 2in.)	**Aerofoil camber**	1/20
Wing chord	6ft 3in.	**Elevator area**	40sq ft
Wing gap	5ft 4in.	**Vertical rudder area**	15sq ft
Length	29ft 9in. (29ft 6in.)	**Weight (empty)**	812lb
Height	Approx. 8ft 0in.	**Weight (gross, with pilot and observer)**	1,216lb (1,379lb)
Wing area	480sq ft	**Wing loading**	Approx. 2.53lb/sq ft (2.87lb/sq ft)
Structure:	Ash, spruce, wire, and unbleached cotton or rubberized fabric with an aluminum powder coating		
Engine:	One water-cooled Wright four-cylinder 28–42hp vertical inline running from 1,425 to 1,500rpm, chain-driving two contra-rotating ("handed") two-bladed propellers; engine weight approx. 4.29lb/hp; bore and stroke, 4⅜in. x 4in.		
	(One water-cooled Sturtevant D-4 four-cylinder 55hp vertical inline running at 1,700rpm, chain-driving two contra-rotating ["handed"] two-bladed propellers; engine weight approx. 4.00lb/hp; bore and stroke, 4½in. x 4in.)		
Maximum speed:	44mph (43mph)		

At the beginning of 1911, the Signal Corps ordered two Model B Flyers (adding a third subsequently) and a Burgess F. Pending their delivery, Robert J. Collier, owner-publisher of *Collier's Weekly* and an aviation benefactor best remembered for having established the Collier Trophy aviation award, loaned the Army his personal Model B. The Army sent it to Texas and the Wrights contributed pilot Phillip Parmelee. On March 3, Parmelee and Foulois completed a remarkable 106-mile nonstop border flight from Laredo to Eagle Pass. On their return, they force-landed in the Rio Grande after inadvertently shutting off the engine, being rescued by a lone cowboy.

The Signal Corps' first two Model Bs entered service in the spring of 1911, sent to the Army's new test and training center at College

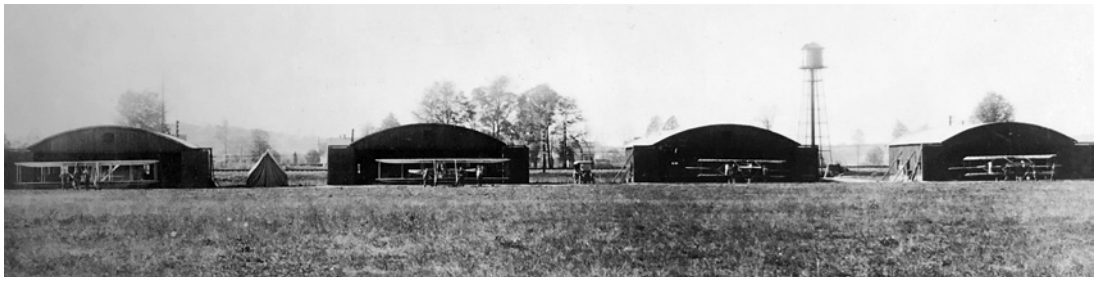
THE FIRST MACHINE-GUN TRIAL

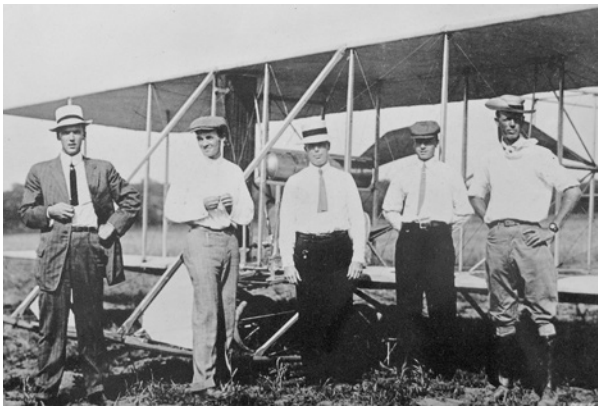
On Friday, June 7, 1912, Col Isaac N. Lewis, inventor of the Lewis machine gun, visited the Signal Corps Aviation School at College Park, and asked if the pilots would be willing to fire his new machine gun from an airplane. The commander of the school, Capt Charles deForest Chandler, swiftly agreed, and within minutes had strapped the Lewis gun – which weighed slightly over 25lb, and which fired at a rate of 500 rounds per minute from a 50-round circular drum – onto the right-seat foot-rest of a Wright Type B (S.C. 4). A small ground target measuring 6ft x 7ft was cut out of cheesecloth and spread on the ground in front of the hangars.

Chandler strapped into the right seat of the Wright, cradling the Lewis gun between his legs and holding it close to his body. While it could not be pivoted or elevated, he could affect minor changes in trajectory by shifting the gun slightly left or right. Likewise, there were no sights on the machine gun, and Chandler had to "guesstimate" the proper firing track. Capt Thomas Milling flew the aircraft, climbing out and circling to pick up a northerly firing track parallel to the hangars and the Baltimore and Ohio Railway Line. Altogether, flying at 250ft, the plane made three firing passes. Flying at approximately 48mph, the Type B passed over the target in approximately a tenth of a second, and over the three passes Chandler hit the target with five rounds, the first time a machine gun had ever been fired from an airplane. He also fired into fishponds located on the edge of the flying field, to note the distance between the bullet splashes. The next day, Saturday, June 8, witnessed a more extensive trial. Signal Corps mechanics laid out a larger cotton target measuring 6ft wide by 54ft in length, and Milling and Chandler attacked it from an altitude of 550ft (as shown on the cover), hitting it with 14 rounds out of 44 fired, a hit rate of 32 percent. Chandler recalled years later that when reporters informed a spokesman for the War Department's General Staff, "The result was a very clear declaration that airplanes were suitable only for reconnaissance purposes and any thought of battles in the air was merely the fertile imagination of the youthful officers at the flying school."

On Friday, June 7, 1912, Capt Charles deF. Chandler fired a Lewis machine gun from a Wright Model B flown over College Park field by Capt Thomas Milling, the first aerial strafing. Here Chandler (left) is with pilot Lt Roy Kirtland (right), another Army pilot at College Park. (NMUSAF)

Park, and the third went to the Philippines, making its first flight in December. Easier to fly than their predecessors, they served as trainers, explored various missions and uses, and gave the Army its first experience with aircraft. The years 1911–12 were a busy time in flight, and Europe's aviators were no longer lagging behind. For example, at an air show at Tanforan racetrack at San Bruno, California, on January 15, 1911, Lt Myron Crissy dropped homemade bombs from a





Early Army pilots at College Park included (left to right): Capt Paul W. Beck, Lt Henry H. Arnold, Capt Charles deF. Chandler, Lt Thomas De W. Milling, and Lt Roy Kirtland. (LC)

Model B piloted by Phil Parmelee, the first bombing trials from an airplane. But on November 1 that year, flying an Etrich Taube over Libya, Italian Tenente (Lt) Giulio Gavotti dropped the first bombs employed "for real," at Ain Zara in Libya.

College Park was exceedingly busy. On September 11, 1911, its airmen undertook photographic trials, overflying the field and photographing it. A month later, on October 11, Capt Thomas Milling and bombsight designer Riley Scott tested his sight, dropping two 18lb weighted shapes on targets. (Scott later won a Michelin prize for his invention.) Then, on June 7, 1912, Capt Charles deForest Chandler became the first to fire a machine gun from the air, riding in a Model B flown by Milling. This was followed by a more elaborate trial the next day.

Hard-flown, none of the Signal Corps Model Bs nor the lone Burgess F survive. S.C. 3 was inspected and surveyed in 1914. S.C. 4 crashed at College Park on September 28, 1912, killing Lt Lewis Rockwell and mechanic CPL Frank Scott (the first American enlisted serviceman lost in an airplane). S.C. 5 (the Burgess F) arrived at College Park in August 1911, served afterwards in Georgia and Texas, crashed, was rebuilt as a Wright Model C, and then grounded at North Island. S.C. 7, modified with floats and serving in the Philippines, sank in a squall while under tow following engine failure, without loss of life.

Beginning in July 1911, the Navy operated three Model B floatplanes, assigning the first (B-1) to its Engineering Experiment Station across the Severn River from the Naval Academy at Annapolis in Maryland. Flown there and in San Diego, California, B-1 was underpowered until re-engined with a Curtiss motor (certain to have annoyed the Wrights!) and tended to dig in its floats and turn turtle. But it was useful for training and exploring technologies and missions.

LEFT
In early 1911, the Army leased 200 acres at College Park, Maryland, establishing the Signal Corps Aviation School. Bounded by the Baltimore and Ohio Railroad to the west and the Paint Branch of the Anacostia River to the east, the field is shown with a mix of Wright (left) and Curtiss (right) aircraft in front of its four military hangars, the embankment of the railroad visible behind them. (USAF)

A team of Army mechanics at College Park carrying the wing cellule of a Wright Model B on a dirt track running between the hangars and the Baltimore & Ohio railroad line in 1911. The hangar on the right was home to the Rex Smith Aeroplane Company, an early local aircraft manufacturer. (LC)

On January 15, 1911, during an air meet at Tanforan Racetrack, San Bruno, California, Coast Artillery Corps Officer Lt Myron S. Crissy (left) dropped a small pear-shaped bomb of his own design from a Wright Model B flown at 45mph by Phil Parmelee (right) at an altitude of 550ft, heralding the age of the bomber. (NMUSAF)

Lt Alfred Cunningham, the first US Marine Corps aviator, learned to fly in the B-1. Then, flying over the Chesapeake on July 26, 1911, Ens Charles Maddox transmitted, "We are off the water, going ahead full speed on a course for the Naval Academy" from the B-1 to the torpedo boat USS *Stringham* (TB-19), the first wireless message ever communicated from an airplane to a ship.

Flying the B-2 in November 1912, Lt John H. Towers (a future admiral) spotted a submarine in Chesapeake Bay while evaluating using aircraft for submarine detection. Sadly, on June 20, 1913, Ens William D. Billingsley fell to his death from the B-2 as turbulence over the Chesapeake sent it into a dive. Towers, just "along for the ride," miraculously hung on, though he was seriously injured in the resultant crash. The B-3, assembled at Pensacola in 1913, apparently never flew, remaining a "hangar queen" until stricken from the Navy's rolls in February 1916.

In 1912, the Wright Company introduced the Model C, with a stronger structure, less span and area, less camber (for a faster climb rate, though at a shallower angle of climb), greater power (a 50hp six-cylinder Wright engine rather than the standard four-cylinder 30hp engine), and rectangular straight-vertical finlets replacing the angled triangular finlets of the Model B.

The Signal Corps ordered six Model Cs (S.C. 10–14 and S.C. 16) as a special "weight-carrying scout," five with the 50hp six-cylinder engine, and one (for training) with a lower-rated 30hp four-cylinder motor. A second S.C. 10 replaced the first, lost in a 1912 accident,

raising the total to seven. The service also purchased a Burgess-built Wright C, the Burgess J (S.C. 18), powered by a Sturtevant engine, and the old S.C. 5, the Burgess F, was rebuilt as a Model C.

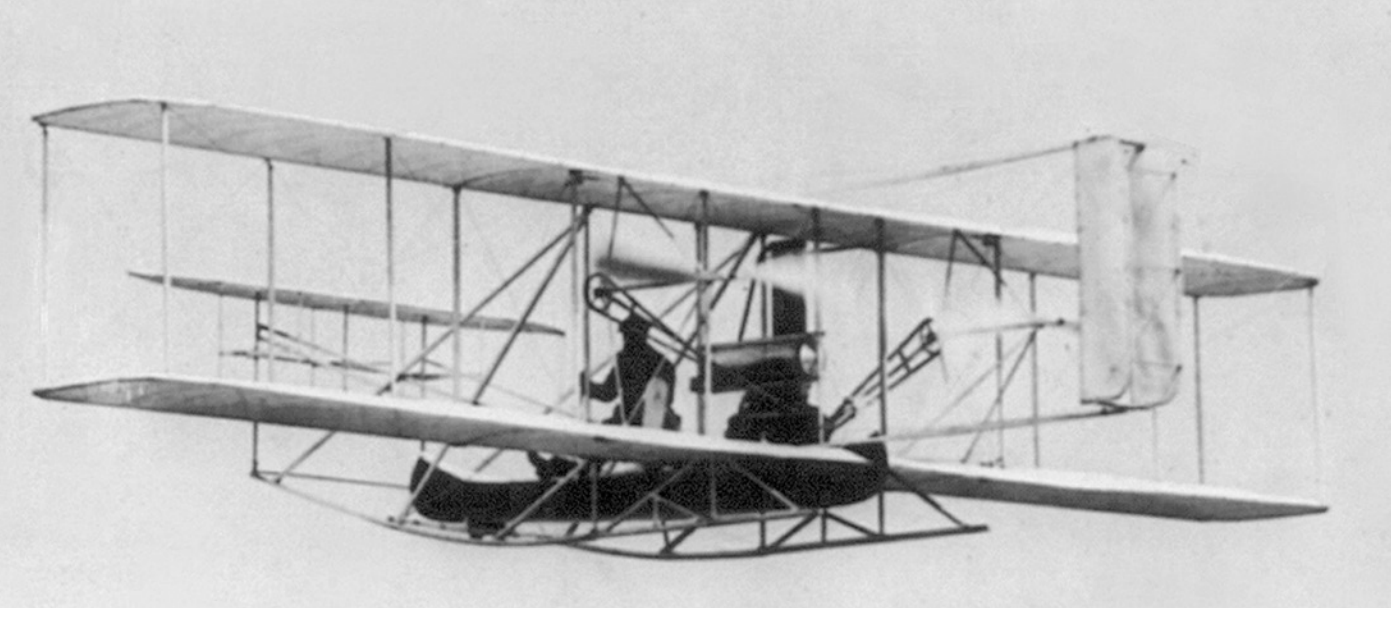
Unfortunately, the Model C, whether Wright or Burgess-built, proved a "Lieutenant Eater," exhibiting lethal flying characteristics that, ironically, it likely would not have manifested were it still a canard. Its dismal record began on June 11, 1912, when Arnold's old instructor Al Welsh and Lt Leighton Hazlehurst perished in S.C. 10 at College Park when it dove into the ground after power application at low altitude, a crash initially attributed to pilot error.

Then, on November 5, 1912, over Fort Riley, Kansas, its replacement (also numbered S.C. 10) nearly killed Lt "Hap" Arnold and a field artillery observer. As they watched troops assembling, the plane abruptly executed an uncommanded horizontal circle, then pitched down into a "whistling nose dive." Arnold recovered and landed but, badly shaken, did not fly for the next four years until persuaded in late 1916 by then-Maj William "Billy" Mitchell.

The year 1913 was a disaster. On July 8, at Texas City, S.C. 11 broke up in a turn, killing Lt Loren Call. On September 4, S.C. 18 (a Burgess J) dove into the ground at San Diego, killing Lt Moss Love. On September 12, S.C. 13 crashed into the sea, fortunately without killing pilot Lt Frank Lahm. On November 14, S.C. 12 dove into the sea, killing Lt C. Perry Rich. On November 24, S.C. 14 crashed into the ground at San Diego, killing Lts Eric Ellington and Hugh Kelly.

On February 14, 1914, S.C. 10 dove into San Diego Bay after climbing more than 12,000ft, killing Lt Henry Post. On February 24, the Army grounded all Model Bs and its last Model Cs – S.C. 5 (the Burgess F rebuilt as a Model C) and S.C. 16 (the Model C with a 30hp engine) – having concluded the design had a dangerous power-on trim instability that produced an unrecoverable nose-over tendency when the pilot applied power. (Orville Wright argued its pilots were simply stalling, thus being the first – though far from the last – manufacturer to blame the pilot, not the plane.) The grounding effectively ended the era of Wright and Curtiss pushers in Army service, and the Navy soon followed. For the American military, the future was tractor airplanes.

SPECIFICATIONS FOR THE WRIGHT MODEL C (BURGESS J DATA IN BRACKETS)			
Wingspan	38ft 0in. (39ft 8in.)	**Aerofoil camber**	1/24
Wing chord	6ft	**Elevator area**	40sq ft
Wing gap	5ft	**Vertical rudder area**	18sq ft
Length	29ft 9in.	**Weight (empty)**	920lb
Height	Approx. 7ft 8in.	**Weight (gross, with pilot and observer)**	Approx. 1,428lb (1,533lb)
Wing area	440sq ft	**Wing loading**	Approx. 3.25lb/sq ft (3.48lb/sq ft)
Structure:	Ash, spruce, wire, and unbleached cotton or rubberized fabric covering with aluminum powder coating		
Engine:	One water-cooled six-cylinder 50hp vertical inline of 240 cubic inch displacement running from 1,400 to 1,560rpm, chain-driving two contra-rotating ("handed") two-bladed propellers; engine weight approx 300lb; bore and stroke, 4⅜in. x 4½in.		
	(One water-cooled Sturtevant D-4 four-cylinder 40–55hp vertical inline running at 1,700rpm, chain-driving two contra-rotating ("handed") two-bladed propellers; engine weight approx 4.00lb/hp; bore and stroke, 4½in. x 4½in.)		
Maximum speed:	54mph (45mph)		



CHAPTER EIGHT

DENOUEMENT

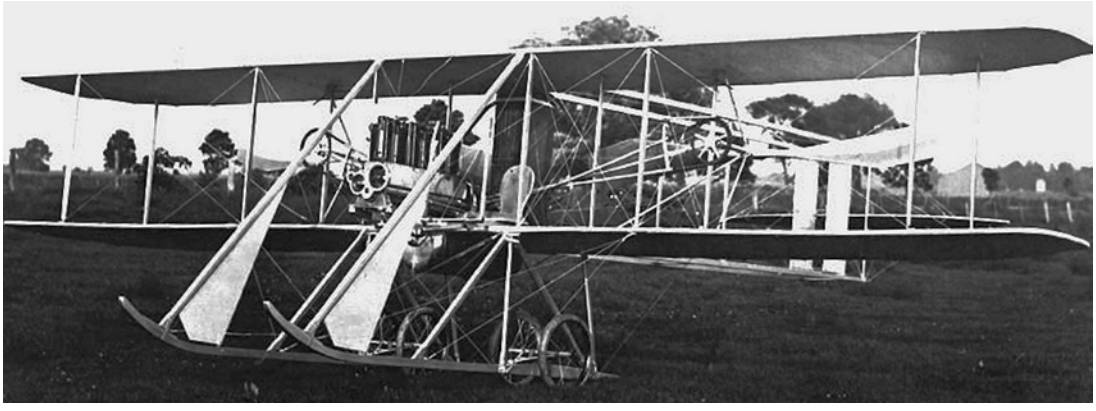
THE WRIGHTS AND THEIR LATER DESIGNS 1910–16

In September and October 1909, Wilbur Wright flew before thousands of New Yorkers during the Hudson-Fulton centenary celebrations, also circling the Statue of Liberty. He is shown taking off from Governor's Island in New York Harbor with a covered and waterproofed canoe affixed to the underside of his Flyer as a streamlined flotation device, on October 4, during which he flew 21 miles, flying well up the Hudson River before returning. (LC)

From 1907 through early 1911, the Wrights secured the patent rights and established an international and domestic business structure befitting aviation's first great aero-industrial enterprise. They received American and German patents in 1906, the French granted patents in 1908, and Britain and Imperial Russia followed the next year. In turn, they granted Lazare Weiller rights for the Compagnie Générale de Navigation Aérienne (CGNA) to build French Flyers in 1907. In 1909, balloon-manufacturers Eustace, Horace, and Oswald Short negotiated rights to manufacture Flyers (thus beginning Short Brothers, one of British aviation's legendary companies) and, later that same year, a German group formed Flugmaschine Wright GmbH to build and sell Flyers through Germany and the Nordic countries. Finally, in January 1911, the brothers licensed W. Starling Burgess to manufacture Wright aircraft in Massachusetts.

Back in America, on November 22, 1909, the brothers oversaw formation of the Wright Company, capitalized at $1 million ($25 million in 2019) – Wilbur Wright was president, Orville first vice president, and Andrew Freedman second vice president. The company broke ground on a Dayton manufacturing plant in January 1910, adding a second building the following year. On paper, then, by the spring of 1911 the Wright organization was strong, well-capitalized, and diverse, with a domestic and international presence.

But a succession of developments worked against the Wrights. Bad business practices hampered the French and German licensees, and



In a bid to regain favor with the military, the Wrights built the single-seat Model D "Speed Scout," powered by a six-cylinder engine and capable of 66mph. But the Army was looking for better performance, and this, plus its high landing speed, doomed its chances for success. (Air Force Historical Research Agency, hereafter AFHRA)

Shorts and Burgess moved beyond the Flyer. In November 1910, Orville Wright found Weiller's CGNA "in very bad shape." It further declined over the next several months, the victim of mismanagement, bad bookkeeping, and unreliable local engines. It produced only a few aircraft, built by a subcontractor, Societé de Constructions Aéronautiques Astra (a firm best known for balloons and small airships), which took over the enterprise and pushed its own designs, Wright finding them "not up to our American standard in either workmanship or finish."

Flugmaschine Wright was healthier, with an impressive factory and a skilled workforce producing first-rate airplanes. But it had an "entirely incompetent" business manager and so many "tangled up" connections with other businesses that Wright had "little hope of its ever being successful." And, indeed, Astra and the German firm were never more than minor players in airplane manufacturing.

Shorts was very well run and highly successful in what it set out to do – building copies of Wright Flyers and some aircraft of its own inspired by them – but like other European manufacturers, it increasingly turned towards France's Blériot, Farman, and Voisin, before moving firmly into the tractor biplane camp.

The Burgess company, reflecting W. Starling Burgess' own wishes and personality, went to great lengths to produce extremely high quality Wright aircraft, but at a loss. It, too, soon moved away from Wright designs, instead developing a series of aircraft inspired by Glenn Martin, Glenn Curtiss, and most notably, John W. Dunne, father of the tailless flying wing.

Indeed, the Wrights' greatest problem was simply the steadily obsolescing Flyer at a time when aviation technology was so rapidly transforming that, in retrospect, it was naïve for the Wrights to ever think they could establish an international chain of aircraft suppliers that could satisfy a post-1909 market with a design configuration already almost a decade old. When the Flyer was the only fully controllable airplane in the world, it had possessed a unique cachet. But once other designers adopted its three-axis flight control system – with or without observing the niceties of patent law – its deficits in stability, flight controls operation (the Wilbur and Orville systems), and canard layout

swiftly broke any other allegiance to it that they may have possessed. Thus, neither the Model B nor its successor, the Model C, returned the Wrights to the prominence they had enjoyed up to 1909. Worse, by establishing a virtual template for later Wright aircraft of the post-1910 period, they ensured the company would produce designs that were, if not outright obsolete, certainly obsolescent at the time they flew.

A case in point is the Model D, built to meet a February 1912 Army specification for a high-speed scout, and rightly judged by historian Robert Casari as "the ultimate development of the Wright aeroplane configuration." While the Model C was built for Corps-level tactical reconnaissance over the battlefield, the Model D was intended for deeper Army-level strategic reconnaissance, a single-seat, go-far, get-in-and-get-out speedster, the partnering of the two types hopefully furnishing a ground commander with the "total picture" needed to prosecute operations from the forward edge of battle to deep in the enemy's rear. But the D was not a success. The only two built (S.C. 19 and 20) flew with Wright, not Army, pilots. S.C. 19 attained 66.9mph during speed trials on January 30, 1913, but engine trouble prematurely ended an endurance test. Rebuilt after flipping over on landing, and regarded as too hot for the average pilot, it passed from College Park to Texas City to San Diego, never reassembled. S.C. 20, banished to San Antonio, likewise never flew, and both had disappeared by mid-1914.

SPECIFICATIONS FOR THE WRIGHT MODEL D			
Wingspan	26ft 6in.	**Aerofoil camber**	1/20
Wing chord	3ft 6in.	**Elevator area**	27.2sq ft (est.)
Wing gap	3ft 6in. (est.)	**Rudder area**	10.2sq ft (est.)
Length	24ft 11in.	**Weight (empty)**	825lb
Height	Approx. 7ft 0in.	**Weight (gross, with pilot)**	Approx. 1,270lb
Wing area	Approx. 180sq ft	**Wing loading**	Approx. 7.05lb/sq ft
Structure:	Ash, spruce, wire, and unbleached cotton or rubberized fabric covering with aluminum powder coating		
Engine:	One water-cooled six-cylinder 50–75hp vertical inline of 406 cubic inch displacement running from 1,400 to 1,560rpm, chain-driving two contra-rotating ("handed") two-bladed propellers; engine weight approx 4.0lb/hp; bore and stroke, 4⅜in. x 4½in.		
Maximum speed:	67mph		

Then there was the brothers' overconfidence. The Wrights took their own technological superiority as a given, Wilbur Wright even writing to Octave Chanute on October 10, 1906, stating that, "We do not believe there is one chance in a hundred that anyone will have a machine of the least practical usefulness within five years." But in just three years, European manufacturers (and Curtiss in America) would be building – and selling – better airplanes than the Wrights. In five years, Italy would send an air expeditionary force of two Blériots, three Nieuports, two Etrich Taubes, and two Farmans to Tripoli – thus becoming the world's first nation to employ airplanes in war, and of different national origins as well.

For example, the Wrights had always prided themselves on their engines, going from four-cylinder horizontal to six-cylinder vertical configurations, with a consequent rise in horsepower, and criticizing some of their rivals (and particularly foreign engine manufacturers) for

RIGHT
The Wrights gradually came to recognize that their Flyer was very difficult for ordinary pilots to fly. In an effort to improve stability they reduced and then eliminated wing anhedral. In 1909, they also added a horizontal tailplane to a Model A, shown here on a 1910 flight over Huffman Prairie. Known as the A-B, it began the transition that resulted in the Wrights eventually abandoning the canard configuration entirely. (LC)

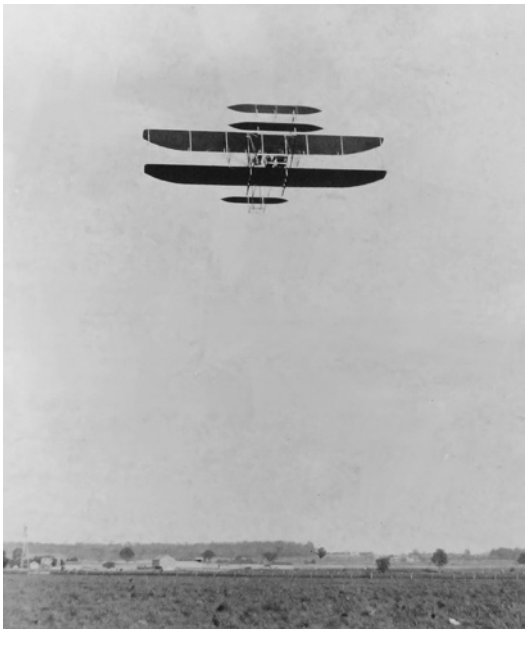
not matching them. "The Wrights had a surprisingly thorough grasp of the metallurgy of the time," Leonard "Luke" Hobbs (designer of the Pratt & Whitney J57 turbojet) wrote, "and their choice of materials could hardly have been improved upon." Yet despite this, as engine technology rapidly advanced (the Curtiss inlines and France's Gnôme rotary only being the most obvious examples), Wright engines grew less reliable, suffering, in particular, from lubrication problems and exhaust valve failures, eroding pilots' faith in them.

SELECTED WRIGHT ENGINE SPECIFICATIONS AND PERFORMANCE, 1903–15*				
	1903 Kitty Hawk Flyer	**1904–05 Flyers**	**1908–11 Flyers**	**1911–15 Aircraft**
Type	Horizontal	Horizontal	Vertical	Vertical
Cylinders	4	4	4	6
Bore & Stroke (in.)	4 x 4	4⅛ x 4	4⅜ x 4	4⅜ x 4½
Displacement (in.)	201	214	240	406
Horsepower	8.25–16	15–21	28–42	50–75
Revolutions per Minute	670–1,200	1,070–1,360	1,325–1,500	1,400–1,560
Mean Effective Pressure (psi)	49–53	52–57	70–87	70–94
Weight (lb)	140–180	160–170	160–180	265–300

*This table does not include the eight-cylinder Wright racing engine installed in the 1910 Baby Grand racer, comprised of two four-cylinder engines joined in a 90-degree V. Other details of it are lacking and thus performance data and specifications cannot be presented with any certainty.
Source: Leonard Hobbs, *The Wright Brothers' Engines and Their Design* (Smithsonian Institution, 1971), pp.47–48, 62.

PUBLIC SPECTACLES

The Wrights welcomed public demonstrations and races, particularly after their great rival, Glenn Curtiss – who had formed his own company in February 1909, partnering with the Wrights' other nemesis, Augustus Herring – sold one of his aileron-equipped airplanes (the first aircraft offered for sale in America) to the Aeronautical Society of New York on June 26, 1909, effectively the first broadside of the patent war.



Recognizing the value of good publicity, in September and October 1909, Wilbur Wright flew before thousands of New Yorkers during the Hudson-Fulton centenary celebrations, circling the Statue of Liberty and flying 21 miles up the Hudson River, scoring a significant public relations coup over his rival, who could not fully participate because of other commitments. Ironically, however, the Wrights rejected two opportunities to achieve extraordinary attention: flying across the Channel from France to Britain, which they easily could have accomplished before Blériot, and taking off and landing on a ship, which they rejected and which Curtiss, with pilot Eugene Ely, eagerly snapped up.

Seeking to win the public eye, the brothers established a Wright Exhibition Company under

The Wrights' Pyrrhic patent fight

Much of the Wrights' difficulties could be traced to their patent wars with their rivals, chief of whom was the shrewd and implacable Glenn Curtiss. At the end of December 1909 the brothers had hoped to "devote most of our time to experimental work." Instead they had to devote their time to waging courtroom battles. "We wished to be free from business cares so that we could give all our own time to advancing the science and art of aviation, but we have been compelled to spend our time on business matters instead during the past five years," Orville Wright wrote to a French friend in January 1912, adding, "When we think what we might have accomplished if we had been able to devote this time to experiments, we feel very sad."

Legally, the Wrights were "right" in the patent fight, and the family's disputatious nature would brook no compromise. But victory – and a Pyrrhic one at that – came at the price of missed opportunities for innovation and advancement that may, in the long run, have saved the company. Where technology is ultimately decided is in the marketplace, not the courtroom, and the Wrights were doomed if they thought they could maintain market advantage and control over aeronautics simply by engaging – no matter how justified they were – in a series of increasingly costly skirmishes and battles that expended capital, time, and concentration. In the end, only the lawyers won.

How great that expenditure was is evident in how the fight dominates Wright correspondence from the summer of 1909 onwards. The depth of the mutual bitterness and no-holds-barred nature of the struggle is evidenced in the lengths to which both sides went in an effort to win, and the casualties and consequences along the way. Curtiss consulted with Henry Ford (who had won a pivotal patent battle involving auto design) and Smithsonian Secretary Charles Walcott, going so far as acquiring Langley's old *Great Aerodrome,* extensively modifying it to "prove" it could have flown before the Wrights, and then "flying" it in a few skipping trials off Lake Keuka in upstate New York. The Wrights flew a Curtiss design to assess its flight control system.

The patent fight broke many old friendships and associations, including the brothers' ties to the Smithsonian Institution. When Walcott, a close friend of Langley, used the hops off Lake Keuka to justify claiming Langley had created the world's first airplane, he destroyed relations with the Wrights. In 1928, Orville sent the 1903 Kitty Hawk Flyer to Britain's Science Museum, where it might well have remained to this day, save for another Smithsonian Secretary, Charles Greeley Abbott, who courageously issued a damning report in 1943 repudiating the Institution's previous leadership. The Flyer returned to America, where, fittingly, it went on exhibit in the National Air Museum (now the National Air and Space Museum) on December 17, 1948.

Worst of all, the patent fight directly contributed to Wilbur Wright's death at age 45, removing from the presidency of the company the most energetic and far-seeing of the brothers, as well as the most technologically adept. During 1911–12, he was traveling and testifying in four lawsuits, as well as running the company. Physically worn out, he contracted typhoid fever on one of his trips, dying at home on May 30, 1912, his father Bishop Wright penning, "A short life, full of consequences. An unfailing intellect, imperturbable temper, great self-reliance and as great modesty, seeing the right clearly, pursuing it steadfastly, he lived and died."

Overall, in courtrooms, the patent fight went the Wrights' way, but it crippled both their own progress and American aviation more broadly. In 1917, the National Advisory Committee for Aeronautics oversaw formation of a private consortium, the Manufacturers' Aircraft Association (MAA), that, like the American automobile industry earlier, established a cross-licensing agreement so that its members could pool patents and produce aircraft without paying exorbitant royalties. The MAA continued into the jet age before being disestablished in 1975.

Roy Knabenshue in March 1910. Orville Wright subsequently trained five pilots at Montgomery, Alabama (flying from a field that is now, fittingly, a part of Maxwell Air Force Base, home of the US Air Force's Air University), among whom were future company stars Arch Hoxsey (who flew former President Theodore Roosevelt at St Louis in a Wright B in October 1910), Walter Brookins (first American to fly over a mile in altitude), and Al Welsh (who taught future Army Air Forces chief of staff Henry "Hap" Arnold to fly).

The training airplane Wright employed was the so-called Model A-B, an interim design. Removing anhedral had greatly improved the basic Flyer's lateral-directional (roll-yaw) handling qualities, but it remained unstable in pitch, and having to constantly adjust the

all-moving canard elevator imposed a tiring chore for the pilot. So in 1909 the brothers took a Model A, and added a fixed horizontal stabilizer aft of the rudder. The resulting aircraft, known to history as the Model A-B, launched the brothers down the path towards abandoning the canard configuration altogether, which they did with the "headless" Model B and subsequent models. Having accomplished this, the A-B introduced the Exhibition Company's candidates to flight.

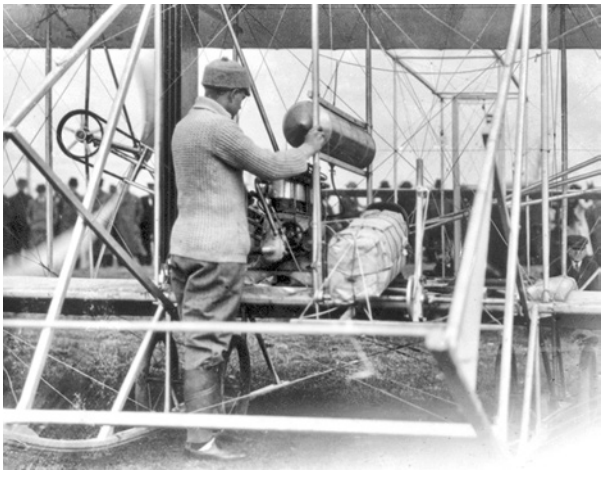
At the Belmont Park meet in October 1910 – America's first international air show, held at a Long Island race track – the rival Curtiss and Wright teams competed against themselves and an international cast of crack aviators including Britain's Claude Graham-White. The Wrights entered Model Bs, a Model R (a racing derivative of the Model B, flown by British pilot Alexander Ogilvie, known as the "Roadster" and also as the "Baby Wright"), and an even smaller racer derived from the Model R, the Wright "Baby Grand," powered by a specially built 60hp V8 Wright engine. With its wingspan almost exceeded by its combined propeller diameters, the Baby Grand promised spectacular take-offs and climbs, anticipating later short-take-off-and-landing (STOL) aircraft. During its first flight at Simms Station on October 22, 1910, Orville Wright flew at nearly 80mph, making it a certain favorite to win the Gordon Bennett speed contest and frustrating any hopes the Curtiss team might have of duplicating their 1909 win.

SPECIFICATIONS FOR THE WRIGHT MODEL R "ROADSTER" AND "BABY WRIGHT"			
Wingspan	26ft 6in.	**Aerofoil Camber**	1/20
Wing Chord	3ft 6in.	**Elevator Area**	27.2sq ft (est.)
Wing Gap	3ft 6in. (est.)	**Rudder Area**	10.2sq ft (est.)
Length	24ft 11in.	**Weight (empty)**	750lb
Height	Approx. 7ft 0in.	**Weight (gross, with pilot)**	Approx. 925lb (est.)
Wing Area	Approx. 180sq ft	**Wing loading**	Approx. 5.14lb/sq ft
Structure:	Ash, spruce, wire, and unbleached cotton or rubberized fabric covering with aluminum powder coating		
Engine:	One water-cooled four-cylinder 28–42hp vertical inline of 240 cubic inch displacement running from 1,325 to 1,500rpm, chain-driving two contra-rotating ("handed") two-bladed propellers; engine weight approx. 4.29lb/hp; bore and stroke, 4⅜in. x 4in.		
Maximum speed:	55mph		

SPECIFICATIONS FOR THE WRIGHT "BABY GRAND"			
Wingspan	21ft 5in.	**Aerofoil camber**	1/20
Wing chord	3ft 6in.	**Elevator area**	27.2sq ft (est.)
Wing gap	3ft 6in. (est.)	**Rudder area**	10.2sq ft (est.)
Length	19ft 6in.	**Weight (empty)**	710lb
Height	Approx. 6ft 10in.	**Weight (gross, with pilot)**	Approx. 860lb
Wing area	Approx. 145sq ft	**Wing loading**	Approx. 7.05lb/sq ft
Structure:	Ash, spruce, wire, and unbleached cotton or rubberized fabric covering with aluminum powder coating		
Engine:	One water-cooled eight-cylinder 60hp 90-degree V of 481 cubic inch. displacement running from 1,325 to 1,500rpm, chain-driving two contra-rotating ("handed") two-bladed propellers; engine weight approx. 5.0lb/hp; bore and stroke, 4⅜in. x 4in.		
Maximum speed:	78mph		

The meet started well, when Wright pilot Ralph Johnstone set an altitude record (he achieved a second at the end of the meet). But

engine failure downed the Baby Grand, which crashed during a preparatory flight, fortunately only slightly injuring pilot Walt Brookins, and high winds literally blew Johnstone and Hoxsey around the sky, viewers watching in amazement as their lightly loaded Flyers, engines snarling, drifted backwards through the sky. In the Gordon Bennett race itself, won by Graham-White in a Blériot, Ogilvie placed third in his Wright Model R (which he took back to England). The meet's most memorable aircraft were neither Wright nor Curtiss designs, but France's speedy Blériot and Antoinette. Afterwards, as Tom Crouch (finest of the brothers' biographers) has written, "it was clear that they had lost their technological edge. After Belmont [a 1910 air race] the inventors of the aeroplane resigned themselves to a position back in the middle of the pack."



The Wrights, through their exhibition team, showcased applications of their aircraft. Here, on November 7, 1910, pilot Phil Parmelee prepares to fly 100lb of silk from Dayton to the Morehouse-Martens Company of Columbus. He subsequently covered the 65-mile distance in 71 minutes, for a cost of $5,000 – equivalent to $128,000 in 2019! – the flight constituting the first air cargo delivery in aviation history. (LC)

Sadly, after Belmont, the Exhibition Company's two standouts – Ralph Johnstone and Arch Hoxsey, whom the press alternately dubbed the "Stardust Twins" and "Heavenly Twins" because of their repeated altitude records – perished within weeks of each other. Johnstone died at Denver on November 14, 1910, when his Wright spiraled into the ground. Hoxsey lived to set another altitude record of 11,474ft at Los Angeles on December 26, 1910, but perished five days later when, like Johnstone, his Wright plunged to earth. They were the first Wright team members to perish, but, sadly, would not be the last. (In November 1911, after five of nine team pilots had died flying Wright aircraft, the brothers, having had enough, shut the team down.)

VIN FIZ – SPANNING THE UNITED STATES IN THE WRIGHT EX

As the Wrights shut down their Exhibition team, another drama unfolded in American skies: Calbraith Perry Rodgers' Odysseus-like flight across the United States in the Wright EX *Vin Fiz*. In the fall of

The Wright EX *Vin Fiz*, which made the first transcontinental flight in America, exemplified later Wright designs, dispensing altogether with the canard elevator and relying on a tailplane instead. Here pilot Calbraith Perry Rodgers is shown taking off after one of the 75 stops made during the marathon 84-day (September 17 to December 10, 1911) journey, which included multiple crashes that left the pilot badly battered. (NMUSAF)

VIN FIZ
VIN FIZ
VIN FIZ
THE IDEAL
GRAPE DRINK
VIN FIZ

1910, American newspaper magnate William Randolph Hearst had created a $50,000 prize (approximately $1.3 million in 2019) for the first airman who completed a coast-to-coast flight across the United States in 30 days or less, open from October 10, 1910, through October 10, 1911. "Cal" Rodgers – a graduate of the Wright Aviation School, descended from two of America's most distinguished military families, and robbed of the military career he desired by poor hearing – thought a new Wright design, the Model EX, a small, single-seat derivative of the Wright Model B first test-flown by Orville Wright at Simms Station on May 14, 1911, ideal for Hearst's challenge. Consequently he purchased one, together with spares, from the Wrights for the sum of $5,000 (approximately $130,000 in 2019).

Rodgers financed his flight by partnering with Armour & Company, then marketing a grape-flavored soft drink named "Vin Fiz." In return for emblazoning "Vin Fiz: The Ideal Grape Drink" in large letters resembling grape vines on the underside of the EX's lower wings, Armour paid Rodgers $5 (slightly more than $125 in 2019) for every mile he flew. Armour also funded a support train carrying spare parts and materials, with a Pullman car and coach for mechanics (including Charlie Taylor, on leave of absence from the Wright Company, and paid the then-phenomenal sum of $10 a day; $260 in 2019) and the pilot's relatives.

He took off from Sheepshead Bay, Long Island, on September 17, bound for Long Beach, California. The next day he suffered a crash costing two days for repairs and setting a pattern for the rest of the flight. He reached Chicago on October 8 after two more crashes. By the time he reached Oklahoma, the Hearst prize time limits had expired, but Rodgers continued on simply for the honor of making the first crossing. In Texas he suffered a fourth crash. On November 3, overflying California's Salton Sea, an engine cylinder burst, lacerating his right arm. Fortunately, he glided down to a safe landing. Following repairs, he landed at Pasadena's Tournament Park on the late afternoon of November 5, greeted by a wildly enthusiastic crowd estimated at 10,000, after having covered 4,231 miles in 49 days, the actual flying time being 82 hours and four minutes, giving an average speed of 51.56 miles per hour.

On November 12, he left on the final 30 miles to Long Beach, briefly landed to fix a broken fuel line, took off again, and suffered a total engine failure that led to a near-fatal crash. After convalescing for nearly a month, he finally reached Long Beach on December 10, 84 days after leaving Sheepshead Bay, landing before 50,000 cheering onlookers, battered, and with his crutches strapped to the

The Wrights always retained an affinity for windy Kitty Hawk. On October 24, 1911, piloting a glider based loosely on their Flyers, Orville Wright established a 9-minute 45-second soaring record that lasted nearly a decade until broken by Austria's Wolfgang Klemperer in the Junkers-inspired monoplane *Blaue Maus* (Blue Mouse), which glided for 13 minutes from the slopes of Germany's Wasserkuppe to the town of Gersfeld on August 30, 1921. (LC)

wings. As for the *Vin Fiz*, only its rudder, an oil drip pan, and two wing struts remained of its original structure. Sadly, Rodgers died on April 3, 1912, when he crashed the *Vin Fiz* on the shore near Long Beach after running into a flock of gulls. Rebuilt, the *Vin Fiz* killed yet another airman, Andrew Drew. After having it rebuilt yet again, Rodgers' mother donated it to the Carnegie Institute in Philadelphia. The Smithsonian acquired it in 1934 (ironically having first turned it down in 1912), and it is currently exhibited in the National Air and Space Museum, an unsettling airplane having far greater survivability than its pilots.

SPECIFICATIONS FOR THE WRIGHT EX "*VIN FIZ*"			
Wingspan	31ft 6½in.	**Aerofoil camber**	1/20
Wing chord	5ft 0in.	**Elevator area**	30sq ft (est.)
Wing cap	5ft 0in. (est.)	**Rudder area**	10.2sq ft (est.)
Length	21ft 5in.	**Weight (empty)**	735lb
Height	Approx. 7ft 4in.	**Weight (gross, with pilot)**	Approx. 903lb
Wing area	Approx. 305sq ft	**Wing loading**	Approx. 2.96lb/sq ft
Structure:	Ash, spruce, wire, and unbleached cotton		
Engine:	One water-cooled four-cylinder 28–42hp vertical inline of 240 cubic inch displacement running from 1,325 to 1,500rpm, chain-driving two contra-rotating ("handed") two-bladed propellers; engine weight approx. 4.29lb/hp; bore and stroke, 4⅜in. x 4in.		
Maximum speed:	52mph		

Shortly before the Belmont Park meet, Orville and Wilbur Wright, accompanied by their brother Lorin, their nephew Horace Wright, and the British aviator Alexander Ogilvie, returned to Kitty Hawk to test a glider based loosely upon their Wright B, part of a study effort on automatic stabilization that had long fascinated Orville. The glider had a long projecting nose boom so that a weight could be moved along it, varying the glider's c.g., as well as a vertical fin located ahead of the vehicle for additional directional stability. Between October 16 and October 24, the glider completed more than 90 flights – exact data is lacking – piloted by Orville and, on at least three flights, by Ogilvie. Badgering journalists plagued the party, limiting their research, but there was one notable accomplishment: on October 24, 1911, Orville Wright soared over the dunes for 9 minutes 45 seconds, a record that lasted nearly a decade, anticipating the golden era of gliding and soaring that Germany's Oskar Ursinus began on the Wasserkuppe after World War I. It was a bittersweet milestone, being the Wrights' penultimate contribution to flight, and the last time Wilbur ever trod Kitty Hawk's dunes.

SPECIFICATIONS FOR THE WRIGHT 1911 GLIDER			
Wingspan	32ft 0in.	**Aerofoil camber**	1/20
Wing chord	5ft 0in.	**Elevator area**	40sq ft (est.)
Wing gap	4ft 6in. (est.)	**Rudder area**	16sq ft (est.)
Length (excluding nose boom)	29ft 9in.	**Weight (empty)**	158lb
Height	Approx. 8ft 0in.	**Weight (gross, pilot & 12lb sand balance)**	Approx. 315lb
Wing area	Approx. 300sq ft	**Wing loading**	Approx. 1.05lb/sq ft
Structure:	Ash, spruce, wire, and unbleached cotton		

By 1911, the Wrights had expanded from makeshift manufacturing quarters into a modern industrial plant. Such trappings of success, however, masked their steadily obsolescing approach to flight as European designers matched them, and then went far beyond. (LC)

INTO THE MISTS OF HISTORY

Following the death of Wilbur Wright in May 1912, the Wright Company's fortunes steadily (if not inevitably) declined. In the "front office," Orville Wright, thrust into the presidency upon the death of his brother, withdrew increasingly into his own work, to the frustration of his colleagues, one of whom, Grover Loening, recalled that letters often "would not be answered for weeks," and that Orville would rail against the tractor configuration, telling him, "This type is really an invention of the French and we should not be copying it just to keep up."

In 1913, Wright designed and flew a smaller derivative of the EX, the Model E, which had a single propeller chain-driven from its engine, thus, in effect, making an aircraft similar to contemporaneous European-style pushers such as the Vickers Gun Bus and Voisin Type L, but on a smaller scale. The E, intended for exhibition work and thus easily disassembled and reassembled, drew heavily on the larger Model C. Orville subsequently used it for his research on automatic stability, developing a pendulum-controlled stabilizing system for which he won the Collier Trophy, demonstrating seven circles in flight where he kept his hands off the controls. Yet even here, his triumph was brief. Months later, after working together, Lawrence Sperry and Glenn Curtiss produced a prize-winning gyroscopic stabilizer that was more practical and a herald of future developments, leading, in time, to the practical autopilot.

SPECIFICATIONS FOR THE WRIGHT E			
Wingspan	32ft 0in.	**Aerofoil camber**	1/20 (est.)
Wing chord	5ft 1in.	**Elevator area**	27.2sq ft (est.)
Wing gap	4ft 0in.	**Rudder area**	10.2sq ft (est.)
Length	27ft 11in.	**Weight (empty)**	730lb
Height	Approx. 7ft 0in.	**Weight (gross, with pilot)**	Approx. 900lb
Wing area	Approx. 316sq ft	**Wing loading**	Approx. 2.85lb/sq ft
Structure:	Ash, spruce, wire, and unbleached cotton or rubberized fabric covering with aluminum powder coating		
Engine:	One water-cooled four-cylinder 28–42hp vertical inline of 240 cubic inch displacement running from 1,325 to 1,500rpm, chain-driving a single four-bladed propeller; engine weight approx. 4.29lb/hp; bore and stroke, 4⅜in. x 4in.		
Maximum speed:	55mph		

By the time Europe erupted into war, Curtiss had already shot ahead of his erstwhile rival. Of the first 100 Signal Corps airplanes, more than 30 were of Curtiss manufacture, and only 13 from the Wrights. For the

The Wright Model E was notable for being the first Wright single-propeller design, though still chain-driven from the engine. Intended for exhibition purposes, it could be assembled within an hour, but still did not reverse the company's declining fortunes. (AFHRA)

Navy, the percentage was higher: two-thirds of their aircraft were Curtiss, just one-fifth were Wright. When the Army effectively ended the Wright and Curtiss pusher era, Curtiss could hardly have cared. By then his firm was building the first tractor biplanes that would lead to the famed JN-4 Jenny of World War I, and innovative naval flying boats that would eventually lead to the Atlantic-spanning NC-4 of 1919. Unlike Orville Wright, Curtiss had no problem transitioning into the tractor era.

Undoubtedly goaded by the commercial and military success of Glenn Curtiss' float-equipped pushers, the Wrights responded with their own attempt at a "hydroairplane," the Model CH, first tested along the Miami River by Orville Wright on May 1, 1913. Basically a float-equipped Model C, it initially had long twin floats that exacerbated the Model C's already twitchy handling characteristics during turns. Revised with a Curtiss-style central float and small stabilization floats attached under the vertical fin and at the lower wing tips, it had much more acceptable control characteristics. But Curtiss had the float seaplane market secured, and the CH found no takers.

SPECIFICATIONS FOR THE WRIGHT CH			
Wingspan	38ft 0in.	**Aerofoil camber**	1/25 (est.)
Wing chord	6ft 0in.	**Elevator area**	40sq ft (est.)
Wing gap	5ft 0in.	**Rudder area**	16sq ft (est.)
Length	29ft 9in.	**Weight (empty)**	1,475lb (est.)
Height	7ft 4in.	**Weight (gross, with pilot)**	Approx. 900lb
Wing Area	Approx. 440sq ft	**Wing loading**	Approx. 3.35lb/sq ft
Structure:	Ash, spruce, wire, and unbleached cotton or rubberized fabric covering with aluminum powder coating		
Engine:	One water-cooled six-cylinder 50–75hp vertical inline of 406 cubic inch displacement running from 1,400 to 1,560rpm, chain-driving two contra-rotating ("handed") two-bladed propellers; engine weight approx 4.0lb/hp; bore and stroke, 4⅜in. x 4½in.		
Maximum speed:	45mph (est.)		

In 1913, the Wright Company produced a new prototype, the Wright Model F, designed in response to a Signal Corps specification for an armored reconnaissance aircraft having chrome steel armor sheeting under its forward fuselage, four-hour endurance, and provision to carry a machine gun. Indicating the low regard with which American engines were held, the Army stipulated use of a foreign powerplant. The Wright Company responded with a graceful broad-span tractor biplane powered by a 90hp Daimler engine placed in the nose and having a long extension shaft running aft under the cockpit, chain-driving twin-handed propellers. Designed by Grover Loening, it was

With the Wright Model F, the brothers had attempted to enter the mainstream of Euro-American aircraft design by incorporating an enclosed fuselage and moving the engine to the nose of the airplane, but retaining the chain-drive twin propellers (first as a tractor installation and later reverting to pusher configuration). Powered by an Austro-Daimler engine, it failed to win an Army production order. (NMUSAF)

the first Wright aeroplane with a fuselage, also having a new centralized flight control stick that, emulating the French Deperdussin system, could be maneuvered to control pitch, roll, and yaw.

The Model F's development soon became a dark comedy of errors, with revisions and changes leading to an aircraft that had both Loening's and Orville's flight control systems and then, after Loening left the company in some frustration, to an aircraft with side-by-side seating, Orville-style controls, and pusher propellers. Delivered a year late, it suffered further delays, finally being accepted by the Army in March 1915 when Orville Wright sold it at a loss. Nicknamed the "Tin Cow" and derided as "a lumbersome mass of rattling material," the Model F, though granted serial S.C. 39, was grounded for good in mid-June 1915.

SPECIFICATIONS FOR THE WRIGHT MODEL F			
Wingspan	42ft 0in.	**Aerofoil camber**	1/20 (est.)
Wing chord	6ft 0in.	**Elevator area**	45sq ft (est.)
Wing gap	5ft 0in. (est.)	**Rudder area**	17.75sq ft (est.)
Length	32ft 10in.	**Weight (empty)**	1,000lb
Height	Approx. 9ft 0in.	**Weight (gross, with pilot)**	Approx. 1,600lb
Wing area	Approx. 485sq ft (est.)	**Wing loading**	Approx. 3.30lb/sq ft
Structure:	Ash, spruce, metal alloy, wire, and unbleached cotton or rubberized fabric covering with aluminum powder coating		
Engine:	One Beardmore-built Austro-Daimler 90hp engine chain-driving two contra-rotating ("handed") two-bladed propellers		
Maximum speed:	60mph (est.)		

Before he left the Wright Company, in response to an informal request from the Navy, Grover Loening designed a graceful twin-pusher "Aeroboat," the Model G. Tested in 1913 on the Miami River, it had a metal-clad streamlined hull, stabilizing wing floats at mid-span (later moved to under the wingtips), and wingtip paddles for steering on the water. Its horizontal tail was later moved to the top of the vertical fins, making the modified Model G the world's first T-tail aircraft. Despite its aesthetically pleasing appearance and well-thought-out design, like most late Wright aircraft, it did not achieve great success. Indeed, on

RIGHT
The Wright Model H of 1914 departed from traditional Wright practice in that it had slight wing dihedral. Intended as a "weight carrier" with a 1,000lb (454kg) payload capacity, it retained the awkward chain-drive pusher propeller layout dating to the 1903 Kitty Hawk Flyer. (AFHRA)

The Wright Model G was, in fact, a design by Wright associate Grover Loening, working under the supervision of Orville Wright. Though a well-thought-out two-seat aircraft, it failed to compete successfully against the "hydroairplanes" of Wright rival Glenn Curtiss, then finding favor with the US Navy. (AFHRA)

August 20, 1914, while low over the Miami River, its left wing broke up, sending the plane into the river. Orville Wright and his passenger, Lt Kenneth Whiting, USN, narrowly escaped drowning.

SPECIFICATIONS FOR THE WRIGHT MODEL G			
Wingspan	38ft 0in.	**Aerofoil camber**	1/20 (est.)
Wing chord	6ft 0in.	**Elevator area**	40sq ft (est.)
Wing gap	5ft 0in. (est.)	**Rudder area**	18sq ft (est.)
Length	28ft 8in.	**Weight (empty)**	1,200lb
Height	8ft 0in.	**Weight (gross, with pilot and observer)**	Approx. 1,800lb
Wing area	432sq ft	**Wing loading**	Approx. 4.19lb/sq ft
Structure:	Ash, spruce, metal alloy, wire, and unbleached cotton or rubberized fabric covering with aluminum powder coating		
Engine:	One Wright 6-60 water-cooled six-cylinder 50–75hp vertical inline of 406 cubic inch displacement running from 1,400 to 1,560rpm, chain-driving two contra-rotating ("handed") two-bladed propellers; engine weight approx 4.0lb/hp; bore and stroke, 4⅜in. x 4½in.		
Maximum speed:	60mph (est.)		

The Model H of 1914 represented a small refinement of a design approach first taken with the unsuccessful Model F. Designed for civil and military use, it had dihedral, representing the final overturning of the Wrights' original predilection for anhedral, followed by "flat" wings. It, too, was unsuccessful in winning any production orders.

SPECIFICATIONS FOR THE WRIGHT MODEL H			
Wingspan	38ft 0in.	**Aerofoil camber**	1/15 (est.)
Wing chord	6ft 0in.	**Elevator area**	40sq ft (est.)
Wing gap	5ft 0in. (est.)	**Rudder area**	18sq ft (est.)
Length	26ft 6in.	**Weight (empty)**	1,150lb
Height	Approx. 9ft 0in.	**Weight (gross, with pilot)**	Approx. 2,000lb
Wing area	Approx. 430sq ft (est.)	**Wing loading**	Approx. 4.65lb/sq ft
Structure:	Ash, spruce, metal alloy, wire, and unbleached cotton or rubberized fabric covering with aluminum powder coating		
Engine:	One Wright 6-60 water-cooled six-cylinder 50–75hp vertical inline of 406 cubic inch displacement running from 1,400 to 1,560rpm, chain-driving two contra-rotating ("handed") two-bladed propellers; engine weight approx. 4.0lb/hp; bore and stroke, 4⅜in. x 4½in.		
Maximum speed:	56mph		

In 1915, Orville Wright directed that the Model H be slightly reduced in span and lightened by approximately 100lb in an effort to increase its speed. The resulting aircraft, the HS, still did not achieve market success, though it is notable for being the last Wright design with chain-driven pusher propellers, and the last Wright aircraft to have the firm's characteristic double rudder.

SPECIFICATIONS FOR THE WRIGHT MODEL HS			
Wingspan	36ft 0in.	**Aerofoil camber**	1/25 (est.)
Wing chord	6ft 0in.	**Elevator area**	40sq ft (est.)
Wing gap	5ft 0in. (est.)	**Rudder area**	18sq ft (est.)
Length	26ft 6in.	**Weight (empty)**	1,050lb
Height	Approx. 9ft 0in.	**Weight (gross, with pilot)**	Approx. 1,900lb (est.)
Wing area	Approx. 420sq ft (est.)	**Wing loading**	Approx. 3.30lb/sq ft
Structure:	Ash, spruce, metal alloy, wire, and unbleached cotton or rubberized fabric covering with aluminum powder coating		
Engine:	One Wright 6-60 water-cooled six-cylinder 50–75hp vertical inline of 406 cubic in displacement running from 1,400 to 1,560rpm, chain-driving two contra-rotating ("handed") two-bladed propellers; engine weight approx. 4.0lb/hp; bore and stroke, 4⅜in. x 4½in.		
Maximum speed:	60mph (est.)		

In October 1915, Orville Wright sold his interest in the Wright Company for $1.5 million (equivalent to $38 million in 2019). The brothers' influence, however, lingered on with the Model K twin-floatplane, which still had twin chain-driven – though now tractor – propellers. This two-person floatplane, though descended from the earlier Model G flying boat, had a completely enclosed fuselage of box-like cross-section, and rested on two long floats. The engine was, like the earlier Model F, G, H, and HS, located in the nose and drove the propellers via an extension shaft. The propellers sat much higher than on other Wright machines, presumably to eliminate water impingement upon them during taxiing, take-off, and landing.

The US Navy accepted one Model K, which received the serial AH-23, later renumbered A51, but despite its generally trim and purposeful appearance, and its generous payload capacity, it suffered from engine problems and was not a success, being stricken from the Navy's inventory in February 1917.

SPECIFICATIONS FOR THE WRIGHT MODEL K			
Wingspan	38ft 7in.	**Aerofoil camber**	1/20 (est.)
Wing chord	6ft 0in.	**Horizontal stabilizer**	45.5sq ft
Wing gap	5ft 6in. (est.)	**Elevator area**	20sq ft (est.)
Length	27ft 3in.	**Vertical fin**	3.50sq ft
Height	8ft 6in.	**Rudder area**	8.5sq ft (est.)
Wing area	Approx. 450sq ft (est.)	**Weight (empty)**	850lb
Aileron area (each wing)	14sq ft	**Weight (gross, with pilot and observer)**	Approx. 1,150lb
		Wing loading	Approx. 3.19lb/sq ft
Structure:	Ash, spruce, metal alloy, wire, and unbleached cotton or rubberized fabric covering with aluminum powder coating		
Engine:	One Wright 6-60 water-cooled six-cylinder 50–75hp vertical inline of 406 cubic inch displacement running from 1,400 to 1,560rpm, chain-driving two contra-rotating ("handed") two-bladed propellers; engine weight approx. 4.0lb/hp; bore and stroke, 4⅜in. x 4½in.		
Maximum speed:	80mph (est.)		

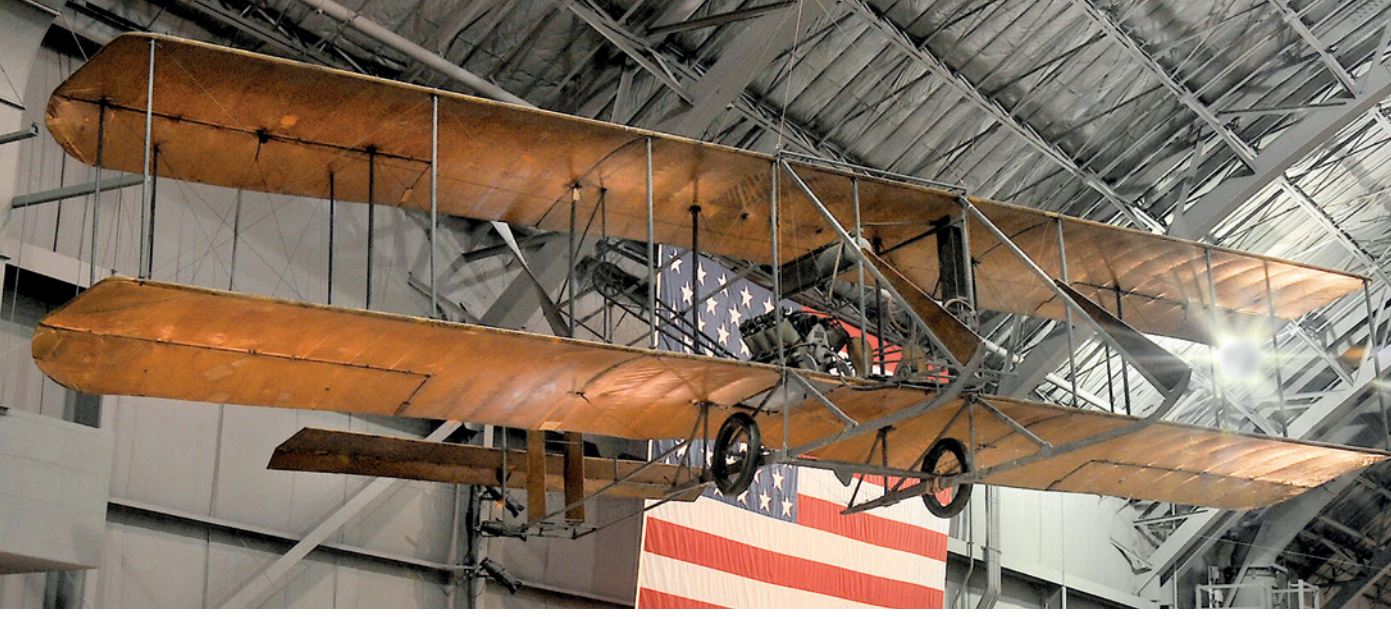
TOP
The Model H gave rise to a smaller derivative, the Model HS of 1915, the last Wright aircraft built with the firm's distinctive twin rudders, and also the last Wright design with pusher propellers. Orville Wright made at least one flight with his sister Katharine in this "one-off" aircraft. (AFHRA)

In 1916, the Wright Company produced its Model L. A slab-sided and relatively unattractive airplane, it represented the antithesis of Wright design philosophy, with tractor propellers, a direct-drive engine, ailerons on both the upper and lower wings, an enclosed fuselage, a wheeled undercarriage, a separate horizontal fin and elevator, and a Fokker-like "comma" tail (though with a separate fin and rudder). Outdated at the time it flew, the aircraft marked the passing of the Wright era in aeronautics, symbolized more dramatically on May 13, 1918. That day, Orville Wright made his

last flight as a pilot, flying a Wright 1911 biplane in formation with a new de Havilland D.H. 4, emblematic of the transformation in flight that had taken place in the years since the Wrights first flew and brought the airplane to the world.

SPECIFICATIONS FOR THE WRIGHT MODEL L			
Wingspan	29ft 0in.	**Aerofoil camber**	1/20 (est.)
Wing chord	6ft 6in.	**Horizontal stabilizer**	45.5sq ft
Wing gap	5ft 9in. (est.)	**Elevator area**	20sq ft (est.)
Length	24ft 2in.	**Vertical fin**	3.50sq ft
Height	10ft 6in. (est.)	**Rudder area**	8.5sq ft (est.)
Wing area	Approx. 360sq ft (est.)	**Weight (empty)**	1,577lb
Aileron area (each wing)	14sq ft	**Weight (gross, with pilot and observer)**	Approx. 2,049lb
		Wing loading	Approx. 4.55lb/sq ft
Structure:	Ash, spruce, metal alloy, wire, and unbleached cotton or rubberized fabric covering		
Engine:	One Wright 6-60 water-cooled six-cylinder 50–75hp vertical inline of 406 cubic inch displacement running from 1,400 to 1,560rpm, driving a single two-bladed propeller; engine weight approx. 4.0lb/hp; bore and stroke, 4⅜in. x 4½in.		
Maximum speed:	62.5mph		

The slab-sided Model L of 1916 was intended as a single-seat high-speed reconnaissance biplane. Though ostensibly a Wright design, it bore no relationship to any of the earlier Wright aircraft, having ailerons in place of wing-warping, a new non-Wright propeller design, and showing strong foreign influence in its design. It typified the passing of the Wright era in aircraft design and the eclipsing of the brothers' aeronautical fortunes. (AFHRA)



CHAPTER NINE

THE WRIGHTS IN RETROSPECT

The National Museum of the US Air Force is home to the 1916 Rinehart Wright B, a modified Wright B used for flight instruction by Howard Rinehart. Equipped with an eight-cylinder Rausenberger engine, trailing-edge ailerons, and a control wheel rather than the Wrights' lever-like system, the Rinehart Wright B thus differed significantly from the basic Wright design. (NMUSAF)

After effectively leaving the aviation industry in 1915, Orville Wright lived on for more than three decades, rightly regarded as both America's and the world's senior statesman of aviation. He passed away peacefully in Dayton on January 30, 1948. That November, the Wright estate reached agreement with the Smithsonian, permitting return of the Wright Kitty Hawk Flyer to America. Fittingly, it went on exhibit on December 17, 1948. Reviewing the Wrights' work – how they invented the airplane, their influence – reveals how distinctive was their work compared to others who unsuccessfully pursued flight.

First is that the analytical and documentary record of their work prior to their history-making flight – their notes, letters, test results, debates, ideas, correspondence with other pioneers (most notably Octave Chanute), discussions, etc – is so voluminous, comprehensive, thorough, insightful, and wide-ranging as to be unmatched by any previous pioneer of flight, certainly anyone who actually attempted to build and fly an airplane. This record alone separates them from all others who sought to be the first to fly. No one prior to them – not even Sir George Cayley (who theoretically conceptualized the airplane a century before the Wrights) and Otto Lilienthal (the first great flight researcher), both of whom the brothers rightly hailed for their contributions and inspiration – left such a voluminous corpus of knowledge. Neither did any of their immediate predecessors and

contemporaries who attempted to build airplanes or gliders, including Sir Hiram Maxim, Clément Ader, Samuel Langley, Octave Chanute, Percy Pilcher, and the less-credible Augustus Herring and Gustav Weisskopf (Gustave Whitehead).

From their documentary record alone, it is evident that, at the time of their triumph at Kitty Hawk (and for some time thereafter), the Wrights, quite simply, knew more about flight than any of their predecessors, and, indeed, more about it than most of their successors. In short, in the international race to fly, they were not simply first among equals, they were without equal.

After Orville Wright left the aircraft industry he was rightly revered as aviation's senior elder statesman. Here he is shown with the balance of the wind tunnel used to design the 1902 glider, and thereby the 1903 Flyer. (LC)

Second is what they actually did, their material contribution to flight. Their insights that the critical problem was control, not just lift and power, that turns required banking, and that the solution was differential lift by varying the camber of the wings, was ingenious, as was their wing-warping approach to physically changing the camber. Using their gliders as progressive testbeds marks them as first-rate flight researchers. Indeed, had they not progressed further than their 1902 Glider – the world's first controllable aircraft – it alone would have ensured a significant place for them in the annals of aviation history.

Designing and flying the 1903 Kitty Hawk Flyer, of course, constituted their signature milestone. But afterwards, the Wrights developed successors that achieved their own series of other "firsts." These included:

- the 1904 Flyer II, the first to complete a circling flight;
- the 1905 Flyer III, the first to carry a passenger and the world's first routinely reusable and practical aircraft;
- the 1907–08 Model A Flyer, the world's first production airplane, and the airplane that introduced the world to the Wrights' work – in short, the airplane that introduced the world to winged flight;
- the 1909 Wright Military Flyer – Signal Corps No. 1 – the first military aircraft;
- its Model B and Model C successors that made pioneering reconnaissance, spotting, machine gun, and bombing trials;
- the 1911 Wright EX *Vin Fiz* that completed the first American transcontinental flight.

That subsequent Wright machines did not match the contributions or significance of these can hardly be held up as a criticism of the Wrights, who had been phenomenally productive over the ten-year period that, from 1899 through 1909, took them – and flight – from a simple warping kite to airplanes that enthralled thousands with their endurance and control.

Today, while replicas abound, only a handful of original Wright aircraft still exist:

- the 1903 Kitty Hawk Flyer that launched the air age, at the Smithsonian's National Air and Space Museum (SI-NASM), Washington, DC;
- the 1905 Flyer, the world's first practical airplane, at Wright Hall, Carillon Park, Dayton, OH;
- the Model A Orville Wright flew in Germany at Tempelhof and Potsdam, at the Deutsches Museum, Munich, Germany;
- the Model B of Grover Bergdoll, which completed at least 748 flights and was flying as late as 1934, at the Franklin Institute, Philadelphia, PA;
- the 1909 Military Flyer, the world's oldest military airplane, at the SI-NASM;
- the Model EX that Calbraith Perry Rodgers flew across the United States, at the SI-NASM;
- The Rinehart Wright, a modified Model B with a control wheel and ailerons, at the National Museum of the USAF, Dayton, OH.

Third is their impact upon their aeronautical contemporaries. By publicly revealing their mastery of winged aviation in such dramatic fashion (beginning with the 139 flights made in France and America in the summer and fall of 1908, and continuing with the further 219 flights in Italy, Germany, and America that the brothers made the following year), the Wrights transformed nascent aviation, inspiring and influencing not only their own countrymen but – among many other pioneers – Britain's Short brothers, Charles Stuart Rolls, J. T. C. Moore-Brabazon, the expatriate American Samuel Cody (born Cowdery), and Geoffrey de Havilland; France's Louis Blériot, Ferdinand Ferber (who sadly died in 1909), the Voisin brothers, and Léon Delagrange; and the Anglo-French Farman brothers.

Together, these 358 flights, and hundreds afterwards by the Wrights and their acolytes, encouraged air-mindedness, stimulated the expansion of military aeronautics – previously restricted just to ballooning and small airships – to include winged aircraft, and encouraged both the rise of private design and manufacturing firms and national investment in aeronautical research and development.

Why couldn't the Wrights compete? Why did they fail to adapt? The easy answer is that they were overconfident, too wedded to a single increasingly outdated configuration, and distracted by a bruising patent fight with fellow American pioneer Glenn Curtiss.

The 1903 Flyer, sent to England and exhibited in the South Kensington Science Museum in 1928, returned to America and exhibition at the Smithsonian Institution in 1948, but only after the Smithsonian issued a corrective report acknowledging the primacy of the Wrights in first achieving powered flight and renouncing claims by previous Institution leaders that Langley's *Great Aerodrome* could have flown. In 1976, it was installed in the new National Air and Space Museum's Milestones of Flight Gallery, seen here. In honor of the centenary of the Kitty Hawk flight, the Smithsonian completely restored the 1903 Flyer and placed it in its own gallery, curated by noted early flight authority Peter Jakab. (Carol M. Highsmith America Project, LC)

There were other factors as well.

Wright aircraft were, quite simply, very difficult to fly. They required great practice, for the marginal stability of their Flyers, particularly the early designs with anhedral and very aft c.g. location, made them prone to pilot-induced oscillations which, at low altitude, could be deadly. The do-everything multi-stick "Wilbur" and "Orville" flight control systems, while functional, were quixotic. Compared to these, later designs by Farman, Blériot, de Havilland, Curtiss, Martin, etc. were both safer and easier to fly, and had simpler flight control systems, leading to the now-standard control stick or control wheel and rudder pedals.

With the death of Lilienthal, the torch of aeronautical supremacy had passed to the United States, and with the flight of Blériot across the Channel in July 1909 it returned to Europe, specifically France. Then, in 1912, the death of Wilbur Wright took the heart out of the Wright enterprise, for he was always the most technically adept, most far-seeing, and most energetic of all the Wright children. That year – the year of Wilbur's death and the year in which Jules Védrines and Maurice Prévost effortlessly proved the supremacy of French aviation in American skies with the elegantly streamlined Deperdussin Monocoque monoplane (more than a third faster than the best Wright machine of the time) – must be counted the bleakest of all years for the Wrights and their enterprise. If anyone could have reversed the Wrights' fortunes, it was Wilbur. Instead, his death accelerated the firm's descent into irrelevancy.

Thus, sadly, when the last Wright airplane with a personal connection to the brothers appeared in 1916 it was anachronistic. The next year, when American airmen went to war, they did so flying the aircraft of others, not those of their own countrymen. Gen John J. Pershing, wartime commander of the American Expeditionary Forces, put it bluntly in his final report sent to the War Department after the war: "In aviation we were entirely dependent upon our Allies." Not until the mid-1930s did American aviation regain its footing.

Given all that, it is tempting to reflexively dismiss the Wrights as heroic achievers who grew overconfident and failed to adapt. But, as Peter Jakab has noted, "It is unfair to criticize Wilbur and Orville for failing to keep pace with the technology to which they had given birth. They had done enough."

Indeed so. The Wrights made transportation three-dimensional, liberating the world from the constraints of two-dimensional surface travel. Ultimately, as Microsoft's Bill Gates said, "Their invention effectively became the World Wide Web of that era, bringing people, languages, ideas, and values together." While it is certainly true that if they had not done so, others would have, they were, nevertheless, first. Their legacy is evident every time an airplane crosses the sky.

This photograph shows the carefully crafted shaping of the Wrights' propellers. Unlike many early pioneers, the Wrights understood the necessity of careful aerodynamics-rooted propeller design, realizing that the propeller was a rotating wing producing a horizontal lift-vector, and thus not merely a paddle or some sort of aerial screw boring its way through the air. As a result, their propellers were surprisingly efficient for their time. (RPH)

As well as the 1903 Flyer, and the transcontinental Wright Model EX *Vin Fiz*, the NASM is home to the 1909 Wright Military Flyer, also known as Signal Corps No. 1, the Army's first airplane, exhibited in the museum's Early Flight Gallery. It still retains its original fabric covering; note the oil and gasoline discoloration under the centre section. (RPH)

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DEDICATED IN GRATEFUL REMEMBRANCE TO CHARLES HARVARD GIBBS-SMITH (1909–81)
Keeper of the Victoria and Albert Museum,
Research Fellow of the Science Museum,
Danish Order of the Dannebrog
Honorary Companion of the Royal Aeronautical Society,
First Charles A. Lindbergh Chair in Aerospace History, National Air and Space Museum of the Smithsonian Institution.
The dean and greatest of all historians of early aviation, he was a wise mentor, boon companion, and treasured friend.
All who study Early Flight follow in his wake

Front Cover
The day after the first firing of a machine gun from an airplane on June 7, 1912, the US Army's Signal Corps carried out a more extensive trial, with the Lewis gun mounted onto the right-seat footrest of Wright Type B (S.C. 4). Signal Corps mechanics laid out a larger cotton target measuring 6ft wide by 54ft in length, and Milling and Chandler attacked it from an altitude of 550ft, hitting it with 14 rounds out of 44 fired, a hit rate of 32 percent.(Cover art by Adam Tooby)

OSPREY PUBLISHING
Bloomsbury Publishing Plc
PO Box 883, Oxford, OX1 9PL, UK
1385 Broadway, 5th Floor, New York, NY 10018, USA
E-mail: info@ospreypublishing.com
www.ospreypublishing.com

OSPREY is a trademark of Osprey Publishing Ltd

First published in Great Britain in 2019

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A catalog record for this book is available from the British Library.

ISBN: PB 9781472837776; eBook 9781472837769;
ePDF 9781472837790; XML 9781472837783

Artwork by Adam Tooby
Index by Alan Rutter
Originated by PDQ Digital Media Solutions, UK